MERRIMACK RIVER BASIN

LYNDEBOROUGH, NEW HAMPSHIRE

SOUHEGAN RIVER WATERSHED
DAM NO. 28

NH 00429

NHWRB 147.26

PHASE I INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

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DEPARTMENT OF THE ARMY

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

WALTHAM, MASS. 02154

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Merrimack River Basin
Lyndeborough, New Hampshire
Temple Brook, tributary of Stony Brook(a tributary of the Souhegan River)

ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The dam is an earth embankment 340 ft. long and 29 ft. high with a drop inlet service spillway structure and a 30 inch outlet conduit. The dam is small in size with a significant hazard potential. In the event of a failure the possibility for appreciable property damage and loss of life could result. The dam is in good ocndition at the present time. No conditions were observed which warrent further investigation.

FORM

SOUHEGAN RIVER WATERSHED DAM NO. 28
NH 00429

MERRIMACK RIVER BASIN
HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION REPORT

NATIONAL DAM INSPECTION PROGRAM

PHASE I REPORT

Identification No.:	NH 00429
NHWRB No.:	147.26
Name of Dam:	SOUHEGAN RIVER WATERSHED DAM NO. 28
Town:	Lyndeborough
County and State:	Hillsborough County, New Hampshire
Stream:	Temple Brook, a tributary of Stony Brook, which is a tributary of the Souhegan River
Date of Inspection:	May 1, 1979

BRIEF ASSESSMENT

The Souhegan River Watershed Dam No. 28 is located on Temple Brook which is a tributary of Stoney Brook approximately 1.6 miles upstream of South Lyndeborough, New Hampshire (Township of Lyndeborough). The dam is an earth embankment 340 feet long and 29 feet high with a drop inlet service spillway structure and a 30 inch outlet conduit. An emergency earth spillway 250 feet wide is cut into the right abutment.

The dam is owned by the New Hampshire Water Resources Board. It was designed by the Soil Conservation Service for the purpose of flood protection in the Souhegan River Watershed.

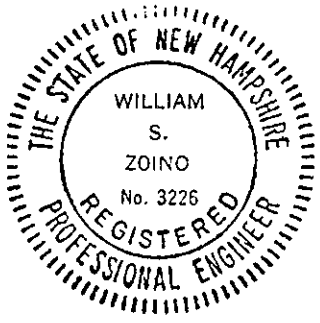
The drainage area of the dam covers 0.95 square miles and is made up primarily of rolling woodland. The dam impounds only 7 acre-feet at low stage but has a maximum impoundment of 24.5 acre-feet. The dam is SMALL in size and its hazard classification is SIGNIFICANT since appreciable property damage and loss of life could result in the event of a dam failure.

The test flood for this dam is one-half of the Probable Maximum Flood. The peak inflow for this flood is 1168 cfs. Because of storage, the resulting peak discharge is 430 cfs compared to a spillway capacity of 2520 cfs. The water surface would be at elevation 851.2 feet (MSL) or 1.8 feet below the top of the dam for this flood.

The dam is in GOOD condition at the present time. Remedial measures to be undertaken by the owner include filling in animal burrows, mowing of slopes, including annual operation of drain gate in the inspection procedure, and developing a

formal written emergency flood warning system for the dam. No conditions were observed which warrant further investigation.

The remedial measures outlined above should be implemented within two years of receipt of this report by the owner, however, the program of annual technical inspections should be continued.



William S. Zoino
N.H. Registration 3226

Nicholas A. Campagna, Jr.
California Registration 21006

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the Test Flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. Because of the magnitude and rarity of such a storm event, a finding that a spillway will not pass the Test Flood should not be interpreted as necessarily posing a highly inadequate condition. The Test Flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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Overview of upstream slope

Overview of downstream slope

— SCALE —

0 1/2 1 2 (MILES)

FROM: USGS PETERBOROUGH & MILFORD - N.H. QUADRANGLE MAPS.

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCUS PLAN

FILE No. 2327

SOUHEGAN RIVER WATERSHED
DAM No. 28

NEW HAMPSHIRE

SCALE AS NOTED
DATE MAY 1979

PHASE I INSPECTION REPORT

SOUHEGAN RIVER WATERSHED DAM NO. 28

SECTION 1

PROJECT INFORMATION

1.1 General

(a) Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The New England Division of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the New England Region. Goldberg, Zoino, Dunnicliff & Associates, Inc. (GZD) has been retained by the New England Division to inspect and report on selected dams in the State of New Hamsphire. Authorization and notice to proceed were issued to GZD under a letter of March 30, 1979 from Colonel John P. Chandler, Corps of Engineers. Contract No. DACW 33-79-C-0058 has been assigned by the Corps of Engineers for this work.

(b) Purpose

1) Perform technical inspection and evaluation of non-federal dams to identify conditions which threaten the public safety and thus permit correction in a timely manner by non-federal interests.

2) Encourage and prepare the states to initiate quickly effective dam safety programs for non-federal dams.

3) Update, verify, and complete the National Inventory of Dams.

(c) Scope

The program provides for the inspection of non-federal dams in the high hazard potential category based upon location of the dams, and those dams in the significant hazard potential category believed to represent an immediate danger based on condition of the dams.

1.2 Description of Project

(a) Location

The Souhegan River Watershed Dam No. 28 is located on Temple Brook approximately 1.6 miles upstream of South Lyndeborough, New Hampshire. It can be reached from an access road off of a town road which intersects State Route 31 in Lyndeborough, New Hampshire. Figure 1 of Appendix B is a site plan for this dam.

(b) Description of Dam and Appurtenances

The dam consists of an earth embankment 340 feet long, a principal spillway with a reinforced concrete riser and outlet pipe, and an earth emergency spillway located at the right abutment. The total length of the dam is approximately 650 feet, of which 250 feet is the emergency spillway and 60 feet is natural ground between the embankment and the emergency spillway.

1) Embankment (See pgs. B-3, B-4, B-6 & B-7)

The embankment is made up primarily of clean sand (Designation SP using the Unified Soil Classification System). It is 340 feet long and is a maximum of 29 feet high. The upstream slope is 3 horizontal to 1 vertical; the downstream slope is 3 horizontal to 1 vertical; and the width of the crest is 14 feet.

The dam is founded in a kame terrace of stratified gravels, sands, and silts at the left abutment. In the center section it is founded in alluvium made up of stratified silt and sand. The right abutment is the end of an esker made up of clean sand over cobbles and decomposed rock.

2) Principal Spillway (See pg. B-5)

The principal spillway consists of a reinforced concrete drop inlet structure with a sluice gate controlled inlet pipe and an uncontrolled orifice inlet and an outlet pipe supported on a concrete cradle.

The riser structure is 9.5 feet high and 7 feet wide normal to the axis of the dam. It is 4.5 feet long parallel to the embankment. The walls of the structure are 12 inches thick and the top slab is 8 inches thick.

At the base of the structure is an 18 inch diameter, vertical lift, sluice gate inlet which is controlled by a wheel operated bench stand with a rising stem. An 18 inch diameter, asphalt coated, corrugated metal pipe extends 15 feet upstream from the lift gate into the impoundment pool. Plans indicate a reinforced concrete inlet structure at the upstream end of this pipe which is protected by a trash rack of painted steel angle sections placed horizontally across the opening.

The "principal spillway inlet" (see pg. B-5) is an uncontrolled opening approximately 6.5 feet above the sluice gate invert. It is 1.5 feet wide and 6 inches high and is located in the upstream face of the riser structure. The water flows over this orifice and drops into the riser structure. It is protected by a trash rack assembly approximately 3 feet high and 2.6 feet wide. This assembly is fabricated from painted steel angle sections.

A 30 inch diameter manhole permits access into the riser structure.

There is a 4 inch diameter galvanized iron vent pipe which penetrates the top of the riser and extends beneath the surface of the embankment to a point near the crest of the dam where it terminates with a 180 degree "U" bend (see pg. B-5).

The riser structure is drained by a 30 inch diameter reinforced concrete pressure pipe. It is approximately 186 feet long and drops approximately one foot over that length. The pipe penetrates the downstream side of the riser structure and is supported by an 8 inch thick concrete cradle within the embankment. Plans indicate 4 concrete anti-seep collars cast around the pipe within the embankment.

The cradle and pipe extend downstream of the embankment and are supported by two precast reinforced concrete piles. The outlet pipe discharges into a stone revetted plunge pool.

3) Emergency Spillway (See pg. B-3)

The grass covered emergency spillway was excavated in earth within the right abutment. It curves to the left around the embankment and is 250 feet wide at the control section. It is approximately 200

feet long and lies approximately 3 feet below the top of the embankment. The side slopes are 4 horizontal to 1 vertical on both sides.

4) Foundation and Embankment Drainage (See pg. B-4)

Toe drains extend from 88 feet to the left of the outlet to 380 feet to the right of the outlet.

At the left abutment the drain consists of a 4 foot wide, clean sand trench drain. Approximately 58 feet left of the outlet conduit, a 10 inch diameter perforated pipe is included in the trench which is made up of clean sand and gravel. This drain discharges approximately 5 feet to the left of the outlet conduit. To the right of the outlet conduit is a similar drain with a perforated pipe which runs approximately 180 feet and discharges to the right of the outlet pipe. Another drain with perforated pipe extends along the downstream toe of the natural slope between the embankment and the emergency spillway, and discharges downstream of the emergency spillway.

The "as built" drawings indicate a chimney drain and blanket extending the full length of the embankment. According to these plans there is a zone of "soil and rock" downstream of this drain.

(c) Size Classification

The dam's maximum impoundment of 245 acre feet and height of 29 feet place it in the SMALL size category according to the Corps of Engineers' Recommended Guidelines.

(d) Hazard Potential Classification

The hazard potential classification for this dam is SIGNIFICANT because of the appreciable economic losses and potential for loss of life downstream in the event of dam failure. Section 5 of this report presents a more detailed discussion of the hazard potential.

(e) Ownership

The dam is owned by the New Hampshire Water Resources Board, 37 Pleasant Street, Concord, New Hampshire 03301. They can be reached by telephone at area code 603-271-3406.

(f) Operator

The operation of the dam is controlled by the New Hampshire Water Resources Board. Key officiels are as follows:

George McGee, Chairman
Vernon Knowlton, Chief Engineer
Donald Rapoza, Assistant Chief Engineer

The Board's telephone number is 603-271-3406. Alternatively, the Board can be reached through the state capital at 603-271-1110.

(g) Purpose of the Dam

The purpose of the dam is to reduce downstream flooding by providing temporary storage for the runoff from 608 acres of watershed. This temporary storage is released through the low and high stage inlets of the principal spillway.

(h) Design and Construction History

The dam was designed by the U.S. Department of Agriculture, Soil Conservation Service in conjunction with the New Hampshire Water Resources Board. It was completed in 1964.

(i) Normal Operating Procedure

The dam is self-regulating. The pond drain gate is operated as part of infrequent maintenance checks.

1.3 Pertinent Data

(a) Drainage Area

The drainage area for this dam covers 0.95 square miles. It is made up primarily of steeply sloping woodland with some pasture and minor development.

(b) Discharge at Damsite

1) Outlet Works

Normal discharge at the site is through the 30 inch diameter outlet pipe. In the event of severe flooding water would flow over the emergency spillway at elevation 850.0 feet (MSL). The invert of the principal orifice is at elevation 831.0 feet (MSL).

2) Maximum Known Flood

There is no data available for the maximum known flood at this damsite.

3) Ungated Spillway Capacity at Top of Dam

The capacity of the principal spillway with the reservoir at top of dam elevation (853.0 feet MSL) is 21 cfs. The capacity of the emergency spillway is 2500 cfs at this level.

4) Ungated Spillway Capacity at Test Flood

The capacity of the principal spillway with the reservoir at test flood elevation (851.2 feet MSL) is 20 cfs. The capacity of the emergency spillway is 410 cfs at this level.

5) Gated Spillway Capacity at Normal Pool

There are no gated spillways with the exception of the gated pond drain inlet which is normally closed.

6) Gated Spillway Capacity at Test Flood

As previously stated, there are no gated spillways.

7) Total Spillway Capacity at Test Flood

The total spillway capacity at test flood elevation (851.2 feet MSL) is 430 cfs.

8) Project Discharge

The total project discharge at test flood elevation (851.2 feet MSL) is 430 cfs.

(c) Elevation (feet above MSL)

1) Streambed at centerline of dam: 824.0

2) Maximum tailwater: Unknown

3) Upstream portal invert diversion tunnel: Not applicable

4) Normal pool: 831.0

5) Full flood control pool: 850.0

6) Spillway crest:

a) Pond drain inlet: 824.5

b) Low stage inlet: 831.0

c) Emergency spillway: 850.0

7) Design surcharge: 851.0

8) Top dam: 853.0

9) Test flood design surcharge: 851.2

(d) Reservoir

1) Length of maximum pool: 2100 ± ft.

2) Length of normal pool: 1050 ± ft.

3) Length of flood control pool: 2100 ± ft.

(e) Storage (acre feet)

1) Normal pool: 7

2) Flood control pool: 187

3) Spillway crest pool:

a) Low stage inlet: 7

b) Emergency spillway: 187

4) Top of dam: 245

5) Test flood pool: 210

(f) Reservoir Surface (acres)

1) Normal pool: 2.5

2) Flood control pool: 16.5

3) Spillway crest pool:

a) Low stage inlet: 2.5

b) Emergency spillway: 16.5

4) Test flood: 17.5

5) Top of dam: 19

(g) Dam

1) Type: Earth embankment

2) Length: 340 ft.

3) Height: 29 ft.

4) Top width: 14 ft.

5) Side slopes: Upstream: 3 to 1
Downstream: 3 to 1

6) Zoning: Semi-pervious sand (SP), chimney drain, "soil and rock" zone in downstream toe

7) Impervious core: None

8) Cutoff: None

9) Grout curtain: None

(h) Diversion and Regulating Tunnel

Not applicable

(i) Spillways

1) Type:

a) Principal spillway: Reinforced concrete Drop inlet

b) Emergency spillway: Grass covered channel cut in earth within right abutment

2) Length of Weir:

a) Pond drain inlet: 18 inch diameter pipe

b) Principal inlet: 1.5 ft.

c) Emergency spillway: 250 ft.

3) Crest elevation (Ft. above MSL)

a) Pond drain inlet: 824.5

b) Principal inlet: 831.0

c) Emergency spillway: 850.0

4) Gates: 18 inch vertical lift sluice gate on pond drain inlet

5) Upstream channel: Reservoir

6) Downstream channel: Narrow man made channel extending approximately 400 ft. to the natural streambed

(j) Regulating Outlet

The only regulating outlet is an 18 inch diameter pipe controlled by a wheel operated sluice gate. The pipe invert is at elevation 824.5 feet (MSL). The purpose of this outlet is pond drainage, and it is normally closed.

SECTION 2 - ENGINEERING DATA

2.1 Design Data

Among other design data available from the Soil Conservation Service are hydrologic and hydraulic computations, structural computations, a geological report, soil laboratory data forms, and stability analysis forms.

2.2 Construction Data

"As built" plans are available for this dam and show good agreement with the design plans and the visual inspection.

2.3 Operational Data

No operational data is available as the dam is self-regulating.

2.4 Evaluation of Data

(a) Availability

Sufficient data is available to permit an evaluation of the dam when combined with findings of the visual inspection.

(b) Adequacy

There is sufficient design and construction data to permit an assessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Validity

Since the observations of the inspection team generally confirm the available data, a satisfactory evaluation for validity is indicated.

SECTION 3 - VISUAL INSPECTION

3.1 Findings

(a) General

The Souhegan River Watershed Dam No. 28 is in GOOD condition at the present time.

(b) Dam

1) Earth Embankment (See overviews)

The earth embankment is generally in good condition. There are three small animal burrows in the downstream slope between the embankment and the emergency spillway. Photo No. 4 is a view of one of these holes. There are tire tracks near the downstream toe of the embankment and some debris on the upstream slope.

The toe drains were functioning with the left toe drain discharging approximately two gallons per minute and the right toe drain discharging approximately ten gallons per minute. The discharge is clear.

3) Emergency Spillway (See photos #1 & 2)

The emergency spillway is in good condition. There is some tree growth at the downstream end of the spillway.

(c) Appurtenant Structure

1) Drop Inlet Service Spillway Structure (See photo # 7)

This structure was completely submerged at the time of inspection. The bench stand and vent pipe appear to be in good condition. Some debris was observed in the trash racks.

2) Pond Drain Inlet Pipe

At the time of inspection the 24 inch pond drain inlet pipe was completely submerged and could not be observed.

3) Outlet Conduit (See photo #5 & 6)

The downstream end of this conduit is in good condition with no evidence of settlement, spalls, cracks, or efflorescence. The supporting cradle is in good condition with the exception of minor spalling (8 square inches) at the downstream end.

(d) Reservoir Area (See photo #3)

The shore of the reservoir is generally steep sloping woodland. It appears stable and in good condition except for a section approximately 100 feet long and 30 feet wide near the left abutment. This section shows recent, very shallow, sloughing of the grass cover. This sloughing is probably due to recent drawdown of the reservoir level after flooding.

(e) Downstream Channel (See photo #5)

The downstream channel consists of a 25 foot plunge pool leading into a gently sloping man-made channel approximately 8 feet wide. This channel extends approximately 400 feet to where it joins the natural channel.

The plunge pool is protected by hand placed rip rap and is stable and in good condition.

3.2 Evaluation

The dam is generally in good condition. The potential problems noted during the visual inspection are listed below:

a) Animal burrows in downstream slope of the embankment.

b) Tire ruts in downstream toe of embankment.

c) Debris in trash racks.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 Procedures

No written operational procedures exist for this dam. The dam is self-regulating.

4.2 Maintenance of Dam

An annual inspection is made jointly by the New Hampshire Water Resources Board and the Soil Conservation Service. Recommendations resulting from this inspection are implemented by the NHWRB.

4.3 Maintenance of Operating Facilities

Operation of the sluice gate for the pond drain inlet is checked approximately once every four or five years by NHWRB.

4.4 Description of Warning System in Effect

There is no warning system in effect.

4.5 Evaluation

The established operational procedures for this dam are generally satisfactory. Additional emphasis on routine maintenance will assist the owners in assuring the long-term safety of the dam.

SECTION 5 - HYDRAULICS/HYDROLOGY

5.1 Evaluation of Features

(a) General

Souhegan River Watershed Dam No. 28 is one of a series of floodwater retarding structures designed by the Soil Conservation Service (SCS) on tributaries to the Souhegan River. This dam, completed in 1964, is located on a tributary to Stony Brook approximately 1.6 miles upstream of South Lyndeborough, New Hampshire. It is an earthfill structure with an orifice controlled principal and a grass-lined emergency spillway channel.

The watershed is hilly and almost completely forested. The drainage area at the dam is 608 acres or 0.95 square miles.

(b) Design Data

The elevation of the low stage inlet was determined by the 50 year sedimentation level of the watershed. The high stage inlet was set to allow storage of the four year, six hour storm without water passing over the high stage inlet. The emergency spillway crest was set to allow storage of the 100 year storm and the top of dam was determined based on the Probable Maximum Flood.

The data sources available for Souhegan Watershed Dam No. 28 include the original Soil Conservation Service (SCS) "Hydrology and Hydraulics" design calculations. These calculations, dated 1963, establish storage-elevation and stage-discharge functions for the dam, and develop flood hydrographs.

The SCS design drawings of the dam and spillway structures along with related outlet and drainage facilities are also available. These are dated 1964.

Additionally, there are SCS "Maintenance Checklist" reports of inspections of this dam dated June 2, 1972 and June 15, 1978.

(c) Experience Data

No records of flow or stage are known to be available for Souhegan Watershed Dam No. 28.

(d) Visual Observations

The earthen embankment rises 29 feet above the natural streambed to an elevation of 853.0 feet above mean sea level (MSL) at the crest. The crest of the dam is roughly 320 feet long, meeting a moderately sloping valley wall at the left abutment and a mild slope at the right abutment in which the emergency spillway has been excavated beginning approximately 30 feet beyond the end of the dam.

The emergency spillway is a grass-lined channel to the right of the dam and slightly upstream of the dam axis. It has been excavated in the natural hillside, except for a small fill area at a depression a little more than 100 feet upstream of the control section. The channel is 250 feet wide at the bottom with side slopes 4 horizontal to 1 vertical and a bottom elevation 850.0 feet MSL, 3 feet below the dam crest. It is difficult to distinguish the beginning of the channel, but a length of 200 feet along the centerline from the entrance to the control section has been adopted for calculation purposes. Beyond the control section, emergency spillway discharges will flow down the ungraded hillside into a gentle swale which will return flows to the main stream channel downstream of the dam.

The principal spillway consists of a concrete riser structure with a single orifice set at elevation 831.0. It is protected by a trash rack.

The spillway riser is drained by a 30-inch diameter concrete pipe which extends 186 feet downstream under the dam. The invert elevation at the riser is 824.0 and at the outlet 822.5.

A riprap-lined stilling pool has been excavated at the exit of the spillway drain pipe. This pool is roughly 25 feet long with a bed 4.5 feet below the pipe invert, and leads to an excavated outlet channel with a bed at elevation 820.5, 2 feet below the pipe invert. Sloping at 0.003 feet per foot, this man-made channel, 8 feet wide with 2 horizontal to 1 vertical sideslopes, extends approximately 400 feet further downstream until it meets the natural stream channel.

This stream flows another one-half mile before it joins Stony Brook. It has a very steep gradient and the nature of the terrain suggests that it is well-confined by steep side slopes along the entire reach. About 200 feet downstream of the point of confluence, Stony Brook is crossed by a railroad bridge with two openings each approximately 30 feet wide and 10 feet high above the streambed. The railroad tracks approach the bridge on the upstream side on a small embankment roughly 12 feet above the streambed level.

For the next mile downstream, Stony Brook flows through a gorge. The stream gradient here is very steep and flow is confined by precipitous sidewalls as high as 50 feet. The railroad recrosses Stony Brook midway along this reach, but this crossing is some 50 feet above the streambed. Beyond this reach, near the village of South Lyndeborough, the stream gradient is somewhat reduced and the sideslopes are considerably flatter allowing for some overbank flooding at high discharges.

At South Lyndeborough, 1.6 miles downstream of the dam, the stream is crossed by a lightly used roadway with a bridge opening 15 feet wide and 6 feet high. Nearby, there are two houses each with first floor level about 15 feet above the streambed.

Shortly beyond South Lyndeborough, Stony Brook enters a reach with steep confining sideslopes (though not a gorge) and a steep channel gradient. This reach is roughly 0.9 miles long. For the next 1.5 miles, the sideslopes are milder providing more floodplain area and the stream gradient is somewhat reduced, though not mild, being on the order of 0.01 feet per foot. In the course of this reach, the stream is crossed twice by Route 31. The first crossing, about 1.2 miles downstream of South Lyndeborough, has an 8.5 foot high by 20 foot wide opening and the second crossing, another 1.2 miles further downstream, has a 12 foot high by 23 foot opening. A short distance upstream of the first crossing there is a house near the brook which is approximately 15 feet above the streambed. Another tributary enters Stony Brook along this reach approximately 1.3 miles downstream of South Lyndeborough. At the end of this reach, approximately 4.0 miles downstream of the dam, Stony Brook is joined by Stockwell Brook.

Beyond this point, Stony Brook follows a channel of straight alignment with high, steeply sloping banks and a steep gradient. A few hundred feet downstream of Stockwell Brook the stream is crossed by a railroad bridge with three openings 40 ± feet wide and 22 ± feet high. Approximately a mile downstream of Stockwell Brook a small, run-of-the-river dam structure has been built with a height of about 8 feet and an impoundment with a surface area of roughly 2 acres.

Further downstream, the high bank at the left recedes from the main channel, leaving a wider flood plain as the stream continues another one-quarter mile into Wilton, where it joins the Souhegan River. In the flood plain along this reach, there are seven houses with first floor levels ranging from 7 to 12 feet above the streambed. Just before entering the Souhegan River, Stony Brook passes the Abbott Dam, another run-of-the-river structure which was the subject of a separate inspection report.

(e) Test Flood Analysis

The hydrologic conditions of interest in this Phase I investigation are those required to assess the dam's overtopping potential and its ability to safely allow an appropriately large flood to pass. This requires using the discharge and storage characteristics of the structure to evaluate the impact of an appropriately-sized Test Flood. The original hydraulic and hydrologic design calculations provided by the SCS were utilized in this analysis.

Guidelines for establishing a recommended Test Flood based on the size and hazard classifications of a dam are specified in the "Recommended Guidelines" of the Corps of Engineers. The impoundment of less than 1000 acre feet and height of less than 40 feet classify this dam as a SMALL structure.

The hazard potential for the Souhegan Watershed Dam No. 28 is considered to fall within the SIGNIFICANT category. This is based on the possibility of some damaging flooding at seven houses along Stony Brook just outside of Wilton, and at a railroad crossing and two roadway crossings of Stony Brook. As the affected houses are 5 miles downstream of the dam, the rate of rise of the flood waters should be relatively slow, reducing considerably the potential for loss of life. Flooding at the road crossings, while damaging, should not be severe enough to seriously endanger the life

of motorists.

As shown in Table 3 of the Corps of Engineers' "Recommended Guidelines," the appropriate Test Flood for a dam classified as SMALL in size with a SIGNIFICANT hazard potential would be between the 100-year flood and one-half times the Probable Maximum Flood (PMF).

The Emergency Spillway Hydrograph developed by the SCS as part of the design calculations is of the order of magnitude of one-half the PMF. The peak value of this inflow hydrograph, 1168 cfs, will be adopted as the Test Flood. In comparison, the Corps of Engineers New England Division's chart for "Maximum Probable Flood Peak Flow Rates" indicates that one-half the PMF for this dam from its 0.95 square miles watershed is approximately 1090 cfs.

After accounting for the effect of storage in the flood control reservoir, the peak outflow through the spillway for this Test Flood was calculated by the SCS to be 430 cfs.

The SCS developed a stage-discharge curve defining discharge as the sum of flow through the principal spillway/outlet structure, and flow over the emergency spillway. The calculations determining these curves are outlined in Appendix D.

Using this stage-discharge curve, the peak discharge of 430 cfs would result in a maximum stage of approximately 851.2 feet MSL, 1.8 feet below the crest of the dam.

(f) Dam Failure Analysis

The peak outflow at the Souhegan Watershed Dam No. 28 that would result from dam failure is estimated using the procedure suggested in the Corps of Engineers New England Division's April 1978 "Rule of Thumb Guidelines for Estimating Downstream Dam Failure Hydrographs." Failure is assumed to occur as soon as the dam crest is overtopped, at an elevation of 853.0 MSL. This is 29 feet above the natural streambed level. Just prior to failure, the normal outflow through the principal and emergency spillways would be 2520 cfs, with a tailwater level estimated to be 25.2 feet below the dam crest. Assuming a 94 foot gap is opened in the dam, the peak failure outflow through this gap would be 22,500 cfs.

Following essentially the "Rule of Thumb Guidelines," it is estimated that at the end of the first 0.5 mile reach downstream of the dam, at the confluence with Stony Brook, the dam failure flood peak would be attenuated to 17,000 cfs. This would have a depth of flow in Stony Brook greater than 14 feet, presenting a hazard to the railroad embankment and bridge just downstream of the tributary.

Using the same storage routing technique over the next one mile reach, the attenuated peak discharge near South Lyndeborough due to the dam break is estimated to be 12,800 cfs. Assuming that this flow is augmented by a flow in Stony Brook of 2,900 cfs (this is approximately a 10-year discharge), the total flow of 15,700 cfs would have a flood depth of about 11. The two houses in this vicinity which are approximately 15 feet above the streambed should not be affected, but the road crossing would probably sustain serious damage.

The Route 31 crossing 1.2 miles downstream of South Lyndeborough is also liable to flood damage under dam failure conditions. The estimated depth of flow there would be 11 to 12 feet, while the bridge opening is only 8.5 feet high. However, the house just upstream of this crossing is about 15 feet above the streambed and should be unharmed. At the next Route 31 crossing, 2.4 miles downstream of South Lyndeborough, the dam break flood wave will have been attenuated to an estimated peak discharge of 4,500 cfs. Including the assumed original Stony Brook flow of 2,900 cfs, the flow depth would be about 11 feet and should safely pass the 12 foot by 23 foot bridge opening.

Another mile downstream, in all 5 miles downstream of Souhegan Watershed Dam No. 28, the attenuated peak flow due to dam failure is estimated to be 3,900 cfs. This discharge (not including the original Stony Brook discharge) would be sufficient to cause serious flood damage to houses in the flood plain along the left bank of the stream there. Based on Flood Insurance Study profiles, flood depths of 10 feet might be expected, causing flooding at seven houses which are 7 to 12 feet above the streambed. This magnitude of flooding is comparable to a natural flood with a return period of between 10 and 50 years.

After further attenuation in the flood plain on the outskirts of Wilton and in the pond behind the Abbott Dam, the flood wave resulting from the failure of Souhegan Watershed Dam No. 28 probably would not be a hazard to the Abbott Dam or to other structures in Wilton.

SECTION 6 - STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

(a) Visual Observations

There has been no significant displacement or distress which would warrant the preparation of structural stability calculations.

(b) Design and Construction Data

1) Embankment

Analysis carried out during the design and construction phase for the earth embankment included a slope stability analysis by the infinite slope and sliding wedge methods. Based on these analyses, a 3 to 1 upstream slope and a 2.5 to 1 downstream slope were utilized.

2) Appurtenant Structures

A review of the structural calculations for the design of the drop inlet service spillway structure and the outlet conduit (primary spillway) revealed that these structures have been designed on the basis of sound engineering practice.

(c) Operating Records

There are no known operating records for this dam.

(d) Post Construction Changes

There have been no known construction changes since the dam was completed in 1964.

(e) Seismic Stability

The dam is located in seismic zone No. 2 and, in accordance with the recommended Phase I guidelines, does not warrant seismic analysis.

SECTION 7 - ASSESSMENT, RECOMMENDATIONS AND REMEDIAL MEASURES

7.1 Dam Assessment

(a) Condition

The dam and its appurtenances are generally in good condition at the present time.

(b) Adequacy of Information

There is sufficient design and construction data to permit an assessment of dam safety when combined with the visual inspection, past performance, and sound engineering judgment.

(c) Urgency

The recommendations and remedial measures described herein should be implemented by the owner within two years of receipt of this phase I Inpsection Report.

(d) Need for Additional Investigations

None

7.2 Recommendations

No conditions were observed which would warrant further investigations.

7.3 Remedial Measures

It is recommended that the owner institute the following remedial measures.

1) Check the operability of the pond drain inlet gate as part of the annual inspection procedure.

2) Develop a downstream emergency flood warning system.

3) Maintain the program of annual technical inspections.

4) Implement and intensify a program of diligent and periodic maintenance including, but not limited to: Backfilling animal burrows in embankment slopes, mowing brush on embankment slopes, and clearing debris from trash racks.

7.4 Alternatives

There are no meaningful alternatives to the above recommendations.

APPENDIX A

VISUAL INSPECTION CHECKLIST

INSPECTION TEAM ORGANIZATION

Date: May 1, 1979

Project: NH 00429
SOUHEGAN RIVER WATERSHED DAM NO. 28
Lyndeborough, New Hampshire
NHWRB 147.26

Weather: Partly cloudy, 65 degrees

INSPECTION TEAM

Nicholas A. Campagna	Goldberg, Zoino, Dunnicliff & Assoc. (GZD)	Team Captain
William S. Zoino	GZD	Soils
M. Daniel Gordon	GZD	Soils
Jeffrey M. Hardin	GZD	Soils
Paul Razgha	Andrew Christo Engineers (ACE)	Structures
Carl Razgha	ACE	Structures
Tom Gooch	Resource Analysis, Inc. (RAI)	Hydrology
Robert Fitzgerald	RAI	Hydrology

Owner's Representative Present

Gary Kerr - New Hampshire Water Resources Board

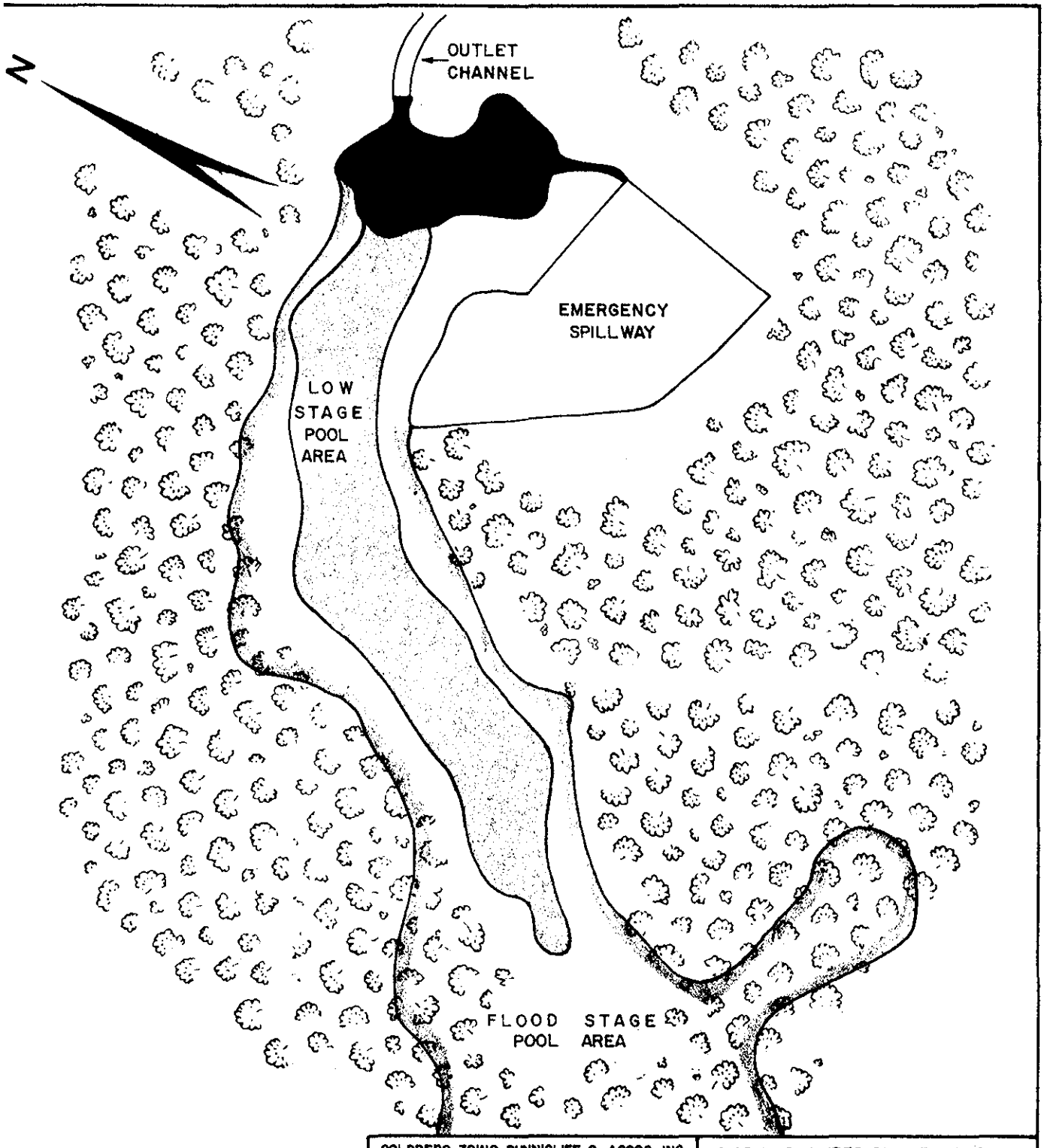
CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
DAM EMBANKMENT		
Crest elevation	NAC	850.0' emergency spillway
Current pool elevation		834.5 ±
Maximum impoundment to date		No data
Surface cracks		None
Pavement condition		Not applicable
Movement or settlement of crest		None
Lateral movement		None
Vertical alignment		Good
Horizontal alignment		Good
Condition at abutment and at concrete structures		Good, drop inlet structure submerged
Indications of movement of structural items on slopes		None
Trespassing on slopes		Many shrubs and trees 2' to 4' tall on up and downstream slopes; 3 rodent holes in natural ground slope near emergency spillway
Sloughing or erosion of slopes of abutments		Upstream left abutment draw-down erosion
Rock slope protection - riprap failures	NAC	No riprap upstream - slope good except as above

CHECK LISTS FOR VISUAL INSPECTION

AREA EVALUATED	BY	CONDITION & REMARKS
Unusual movement or cracking at or near toes	NAC	None
Unusual embankment or downstream seepage		None
Piping or boils		None
Foundation drainage features		Functioning as below
Toe drains		Right toe drain 10-15 gpm Left toe drain 2-4 gpm
Instrumentation system	NAC	None
APPURTENANT STRUCTURES		
A. Drop inlet Service Spillway	PR	
Condition of concrete		Submerged, could not be observed
Trash rack		Submerged, could not be observed
Gate bench stand		No deficiencies noted
Vent pipe		No deficiencies noted
B. Reservoir Discharge Conduit		Submerged, could not be observed
C. Outlet Conduit (primary spillway)		
Condition of pipe		No deficiencies noted
Concrete cradle	PR	Spalled at end, 8 square inches

APPENDIX B



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

SITE PLAN

SOUHEGAN RIVER WATERSHED
DAM No. 28

FILE No. 2327

SCALE 1" = 200'
DATE MAY 1979

N

WORK AREA

LIMIT OF CONSTRUCTION

℄ OUTLET CHANNEL

CLEARING & GRUBBING LIMITS

CLEARING LIMIT

CLEARING & GRUBBING LIMIT

SEEPAGE DRAIN PROPERTY LINE

ACCESS ROAD

TBM 28₄
EL 882.70

TBM 28₁₂
EL 847.42

DH 303

TP 401

DH 302

DH 6

DH 7

℄ OF DAM TOP-WIDTH = 14'
ELEV. 853.0

℄ OF PRINCIPAL SPILLWAY
STA. 11+00 OF DAM = 3+00 OF PR'N. SP.

ELEV. 852.0
10' BERM
ELEV. 851.5

DH 301

INLET CHANNEL

POOL ELEV. 851.0

SEDIMENT POOL

TP 402

TP 1

TP 120

℄ OF EMERGENCY SPILLWAY

FLOODWATER ELEV. 850.0

TP 10 (2)

DESIGN HIGHWATER ELEV. 851.2

CLEARING AND GRUBBING LIMIT

4:1 SLOPE

SLOPE 0.00%

AH 204

AH 205

AH 206

AH 207

AH 102

TP 201

TP 203

E.S. STA 5+00 LINE

ELEV. 850.0

FILL AREA TO BE FILLED TO AN ELEV. OF 850

WASTE AREA TO AN ELEV. NOT LESS THAN 851.0

TBM 28₃
ELEV 835.58

LIMIT OF CONSTRUCTION

WORK AREA

CLEARING LIMITS

CURVE DATA

Δ = 45° 50'
R = 125'
D = 45° 50'
L = 100'
T = 52.84'
E = 10.71'
M = 9.86'
Lc = 97.35'

P.T.A	CHORD	DEFL ∠
P.C. 3+25	0.00	0° - 00'
3+45	19.98	4° - 35'
3+65	19.98	9° - 10'
3+85	19.98	13° - 45'
4+05	19.98	18° - 20'
P.T. 4+25	19.98	22° - 55'

℄ OF DAM

61.25'

4°

250'

2+25

5+00

R = 125'

P.T. 4+25

℄ EMERGENCY SPILLWAY

4+00

P.C. 3+25

FLOW

DH — DRILL HOLE
AH — AUGER HOLE
TP — TEST PIT
FILL AREA

BENCH MARK DESCRIPTIONS

TBM - 28₄ - SPIKE IN ROOT 12" WHITE PINE 36'-N.E STA. 13+25 EL 882.70

TBM 28₁₂ - HORIZONTAL SPIKE IN TRUNK OF 15" HEMLOCK 100' N.E STA. 12+00 EL. 847.42

TBM 28₃ SPIKE IN ROOT OF 15" HEMLOCK 5' S.W. ℄ STA 5+30 EL. 835.58

SCALE IN FEET
0 50 100 150 200

NOTE: DRAWING HAS BEEN REDUCED SCALES ARE NOT AS SHOWN

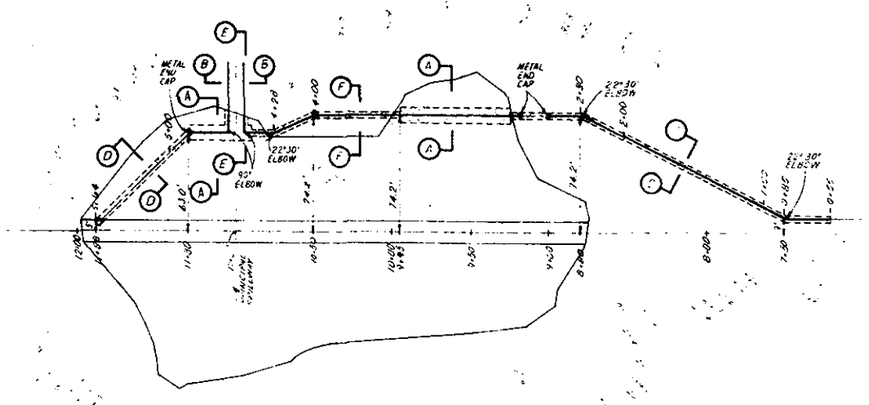
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 28
SO. LYNDEBORO, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PLAN OF DAMSITE

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed H.S.STAMATEL	Date 3/64	Approved by	
Drawn E.F. BENT	3/64	Title	
Traced		Title	
Checked M.E.SIMES	4/64	Sheet No. 3 of 11	Drawing No. NH-621-P

Form SCS-313 (November 1964)



PLAN VIEW

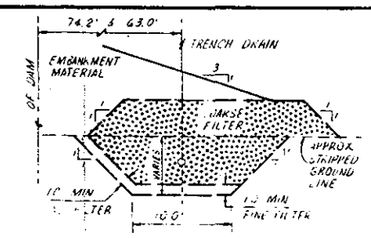
SCALE 0 10 20 30 40 50 60 70 80 90 100 FEET

NOTE:

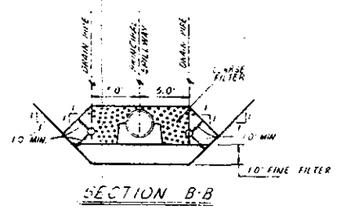
THE SEEPAGE DRAIN PIPES SHALL BE 15" DIA. PERFORATED, ANNULAR CORRUGATED ASBESTOS BONDED BITUMINOUS COATED, CORRUGATED METAL PIPE.

PERFORATIONS SHALL BE 3/16" DIA AND PLACED ON THE LOWER SIDE OF THE PIPE.

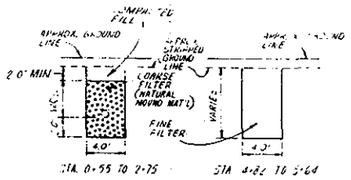
TOTAL LENGTH OF PIPE = 480 FEET



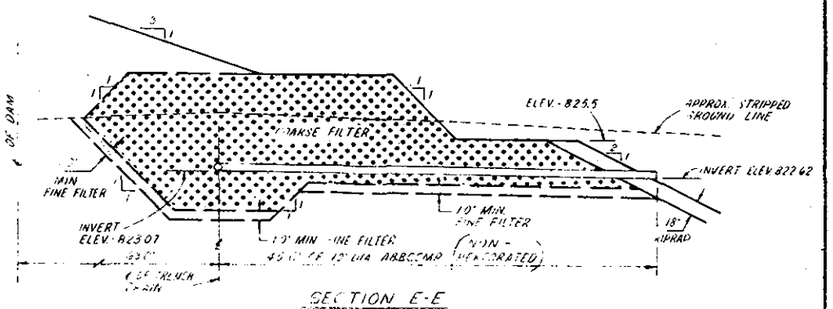
SECTION A-A



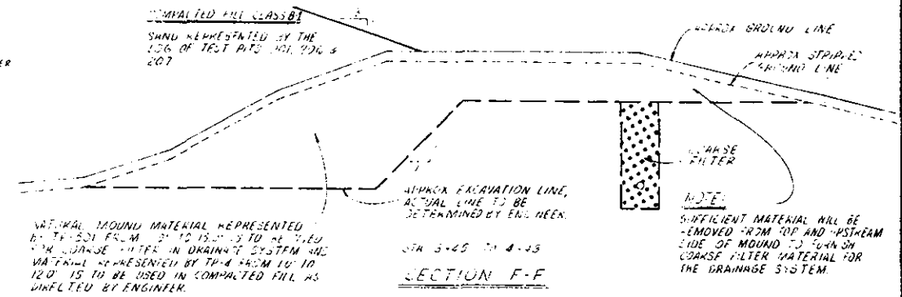
SECTION B-B



SECTION C-C SECTION D-D



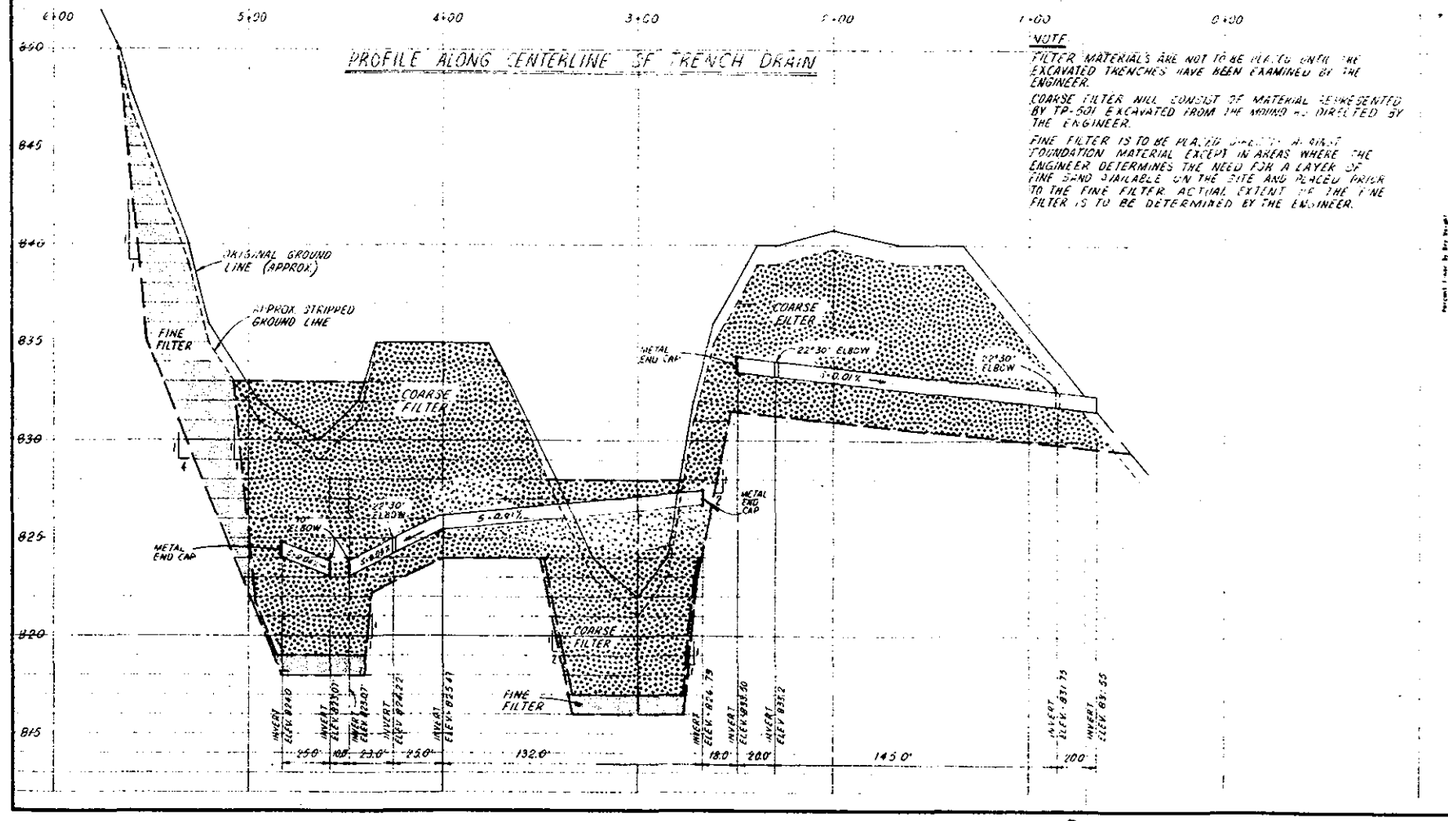
SECTION E-E



SECTION F-F

NOTE:

SUFFICIENT MATERIAL WILL BE REMOVED FROM TOP AND UPSTREAM SIDE OF MOUND TO YIELD ON COARSE FILTER MATERIAL FOR THE DRAINAGE SYSTEM.

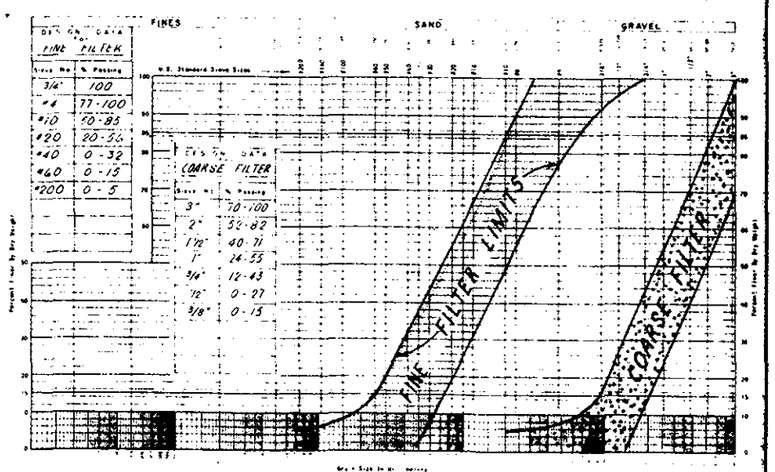


NOTE

FILTER MATERIALS ARE NOT TO BE PLACED UNTIL THE EXCAVATED TRENCHES HAVE BEEN EXAMINED BY THE ENGINEER.

COARSE FILTER WILL CONSIST OF MATERIAL REPRESENTED BY TP-501 EXCAVATED FROM THE MOUND AS DIRECTED BY THE ENGINEER.

FINE FILTER IS TO BE PLACED DIRECTLY ON NATURAL FOUNDATION MATERIAL EXCEPT IN AREAS WHERE THE ENGINEER DETERMINES THE NEED FOR A LAYER OF FINE SAND AVAILABLE ON THE SITE AND PLACED PRIOR TO THE FINE FILTER. ACTUAL EXTENT OF THE FINE FILTER IS TO BE DETERMINED BY THE ENGINEER.



NOTE: DRAWING HAS BEEN REDUCED SCALES ARE NOT AS SHOWN

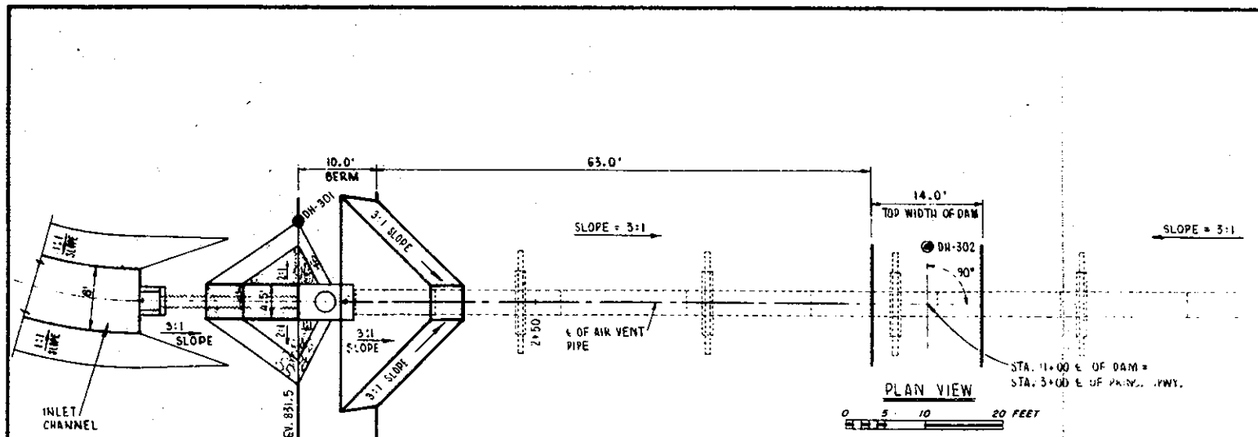
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 28
SO LYNDEBORO, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

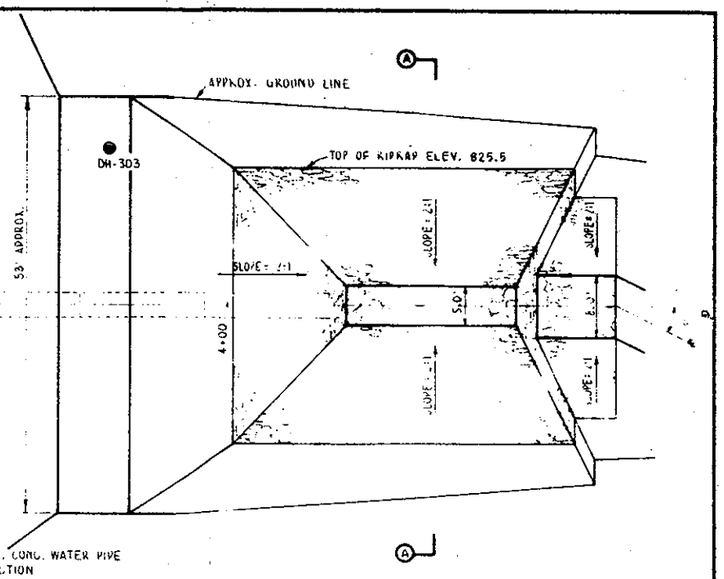
SEEPAGE DRAIN DETAILS

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
S C ROSSIER	6-64	Title
Drawn		
C.B FORD	6-64	Title
Traced		
Checked		Sheet No. 5 of 11
F.M.WYSONG	6-64	Drawing No. NH-621-P

Form SCS-317 (November 1955)

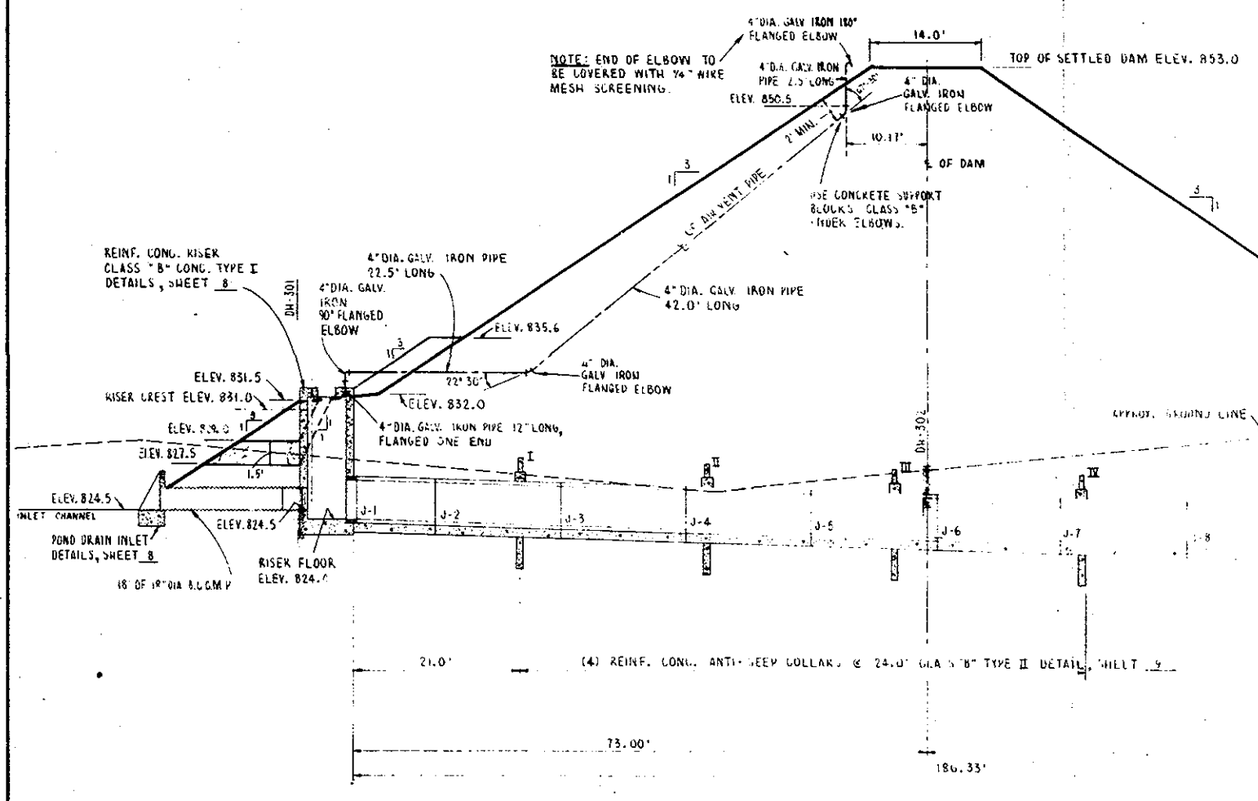




50" I.D. REINF. CONC. WATER PIPE
(1) 10.0' SECTION
(11) 16.0' SECTIONS
(1) WALL PIECE FOR 12" WALL

TOTAL = 187.35'
PRESSURE HEAD = 30.0'
LOAD = 16,197 LBS. PER LIN. BASED ON O.D. OF 2.96'
MIN. 3 EDGE BEARING STRENGTH FOR 0.001" CRACK
= 4,664 LBS. PER LIN. FT. FOR PRESTRESSED PIPE AWWA C-301
MIN. 3 EDGE BEARING STRENGTH FOR 0.01" CRACK = 5671
LBS. PER LIN. FT. FOR NON-PRESTRESSED PIPE AWWA C-302

MFG. SUPPLIERS NOTE:
CAST OUTSIDE OF SPIGOT JOINT RING WITH CONCRETE ON ONE 16.0' SECTION OF PIPE.



JOINT	DISTANCE FROM RISER WALL	INVERT ELEV. OF 30" DIA. PIPE	SLOPE
J-1	0.33	824.00	S=0.00134 ft/ft
J-2	10.33	823.99	
J-3	26.33	823.96	
J-4	42.33	823.94	
J-5	58.33	823.92	
J-6	74.33	823.90	
J-7	90.33	823.10	S=0.01250 ft/ft
J-8	106.33	823.50	
J-9	122.33	823.30	
J-10	138.33	823.10	
J-11	154.33	822.90	
J-12	170.33	822.70	
OUTLET	186.33	822.50	

NOTE: DIMENSIONS FOR LENGTHS OF PIPE ARE BASED ON NOMINAL LENGTHS AND DO NOT INCLUDE CREEP.

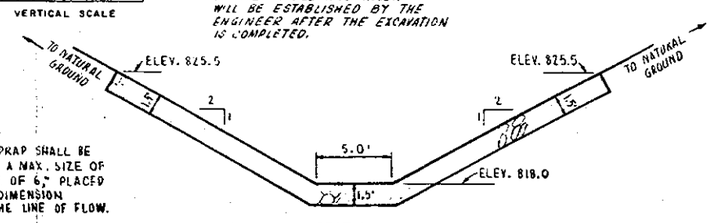
COLLAR	DISTANCE FROM RISER WALL	INVERT ELEV. OF 30" DIA PIPE
I	21.00	823.97
II	45.00	823.94
III	69.00	823.91
IV	93.00	823.67

PROFILE ALONG ℄ OF PRINCIPAL SPILLWAY

0 5 10 20 FEET HORIZONTAL SCALE

0 5 10 FEET VERTICAL SCALE

NOTE:
THE NEAT LINES OF THE BOTTOM OF THE CRADLE AND RISER WILL BE ESTABLISHED BY THE ENGINEER AFTER THE EXCAVATION IS COMPLETED.



SECTION A-A

NOTE:
HAND PLACED RIPRAP SHALL BE WELL GRADED FROM A MAX. SIZE OF 18" TO A MIN. SIZE OF 6" PLACED WITH THE LONGEST DIMENSION PERPENDICULAR TO THE LINE OF FLOW.

NOTE: DRAWING HAS BEEN REDUCED SCALES ARE NOT AS SHOWN

SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 28
SO. LYNDEBORO, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

PLAN-PROFILE OF PRINCIPAL SPILLWAY

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed	Date	Approved by
F.M. WYSONG	5-64	Title
Drawn		
W.H. MORGAN	MAY 64	Title
Traced		
Checked		Sheet No 6 of 11
F.M. WYSONG	5-64	Drawing No NH-621-P

Form SCS-313 (November

DRILL HOLES WITH PENETRATION RESISTANCE AND ROCK CORE BORING

DH 6, STA. C/L + 7, C/L 9 + 44, ELEV. 824.6

N	Symbol	Depth	Description
		0.0	Sand, yellow brown - moist - pervious - loose - glaciofluvial. Topsoil 0.0' - 1.0'
	SP	▼ 7/63	
N = 10	SP	5.0	Sand, pale yellow brown - pervious - loose - 5% gravel - glaciofluvial.
18	SP	10.0	Sand, pale gray - wet - pervious - 5% gravel - glaciofluvial.
276		15.0 / 16.5	Sand to silty sand, gray - wet - semipervious - dense - 10% gravel - glaciofluvial.
NX 88%		21.5	Quartz diorite - fine grained with slight weathering and fractures. Iron stained along some of the fractures. Broken core. Split spoon refusal at 16.5'. Bottom of hole.

DH 7, STA. C/L + 83, C/L 8 + 86, ELEV. 949.9

N	Symbol	Depth	Description
	SP	0.0	Sand, pale yellow brown - slightly moist - very loose - glaciofluvial.
N = 56	SP	5.0	Sand, pale yellow brown - coarse - moist - pervious - dense - glaciofluvial.
66	SP	10.0	Sand, pale yellow brown - pervious - very dense - glaciofluvial.
36	SP / SM	15.0 / 17.0	Sand, silty sand, gray brown - moist - semipervious - 10% fine gravel. Casing refusal at 17.0'.
NX 6%			Nested cobbles or decomposed rock. Complete loss of drill water at 20.9'.
40	SP / SM	26.5 / 30.0	Sand, silty sand, dark gray - moist - pervious - very dense - 15% subrounded gravel particles. Bottom of hole.

DH 301, STA. C + 21, C/L 11 + 10, ELEV. 826.0

N	Symbol	Depth	Description
	ML ▼ 7/63	0.0	Silt, dark gray - moist - impervious - loose.
N = 154	SM	5.0	Sand, silty, pale gray - moist - semipervious - very dense.
60	SP	10.0	Sand, gray - 30% gravel size fragments which are subrounded - wet - semipervious - dense. Split spoon refusal at 16.4'.
154	SP	18.0 / 20.0	Sand, gray - moist - pervious - dense - 5% subrounded gravel. Bottom of hole. Entire profile derived from glaciofluvial materials.

DH 302, STA. C/L + 90, C/L 11 + 05, ELEV. 818.5

N	Symbol	Depth	Description
N = 8	SP	0.0	Sand, pale yellow brown - moist - pervious - loose.
	ML ▼ 7/63	3.5	Silt, pale gray - semipervious - firm
22	SM	5.0	Sand, silty, pale yellow brown - wet - semipervious - firm.
9			
13	ML	15.0	Silt, pale gray - semipervious.
	SM	17.0	Sand, silty, pale gray - semipervious - loose - wet.
21	ML	20.0	Silt, pale gray - semipervious - firm - wet.
	SP	24.0	Sand, pale gray - dense - pervious - wet.
29	ML	25.0	Silt, pale gray - semipervious - firm - wet - hole uncased below 25.0'.
104		30.0 - No RECOVERY 31.0	Bottom of hole. Entire profile derived from glaciofluvial materials.

DH 303, STA. C/L + 83, C/L 11 + 23, ELEV. 829.3

N	Symbol	Depth	Description
	SP	0.0	Sand, pale gray - slightly moist - pervious - loose.
N = 277	SP ▼ 7/63	5.0	Sand, gray brown - slightly moist - semipervious to impervious - 40% subrounded gravel - very dense. Casing refusal at 5.0'.
		15.0	Moist - pervious to semipervious - 10% fine gravels.
		15.0	Bottom of hole. Entire profile derived from glaciofluvial materials.

TEST PITS (BACKHOE)

TP 2, STA. C + 21, C/L 11 + 67, ELEV. 838.0

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	6.5	Gravel, pale gray to reddish brown - very pervious - dense - slightly moist - subrounded particles - 5% stones over 3".	(GP)
6.5	8.5	Sand, coarse to medium, pale yellow brown - dense - moist.	(SP)
8.5	12.5	Silt, moist - semipervious - dense. PP = 2.5T/Sq.Ft.	(ML)
12.5+		Gravel, pale gray - moist - pervious - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(GP)

TP 3, STA. C/L + 71, C/L 11 + 65, ELEV. 836.4

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, yellow brown - moist - pervious - dense.	(SP)
3.0	5.0	Sand, pale yellow - moist - pervious - dense.	(SP)
5.0	6.5	Sand, pale yellow - moist - pervious - dense.	(SP)
6.5	8.0	Sand, pale yellow - subrounded particles.	(SP)
8.0	13.0	Silt, pale olive gray - semipervious - moist - dense. PP - 2.5T/Sq.Ft.	(ML)
13.0	15.0	Sand, pale olive gray - moist - pervious - dense.	(SP)
15.0	18.0	Silty sand to silt, pale olive gray - semipervious - loose to dense. PP - 2.5T/Sq.Ft. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SM/ML)

TP 4, STA. C/L + 45, C/L 10 + 81, ELEV. 835.3

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, reddish brown - moist - pervious - dense.	(SP)
3.0	7.0	Sand, stony, brown - 15% gravel - 15% stones 3-6" - 15% stones 6-12" - 35% stones over 12" - pervious - moist - dense.	(SP)
7.0	12.0	Sand, pale gray - moist to wet - pervious - dense. WL - 11.0' 5/20/63	(SP)
12.0	15.0	Gravel, pale gray brown - wet to saturated - pervious - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(GP)

TP 8, STA. B + 92, C/L 8 + 16, ELEV. 849.2

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, with alternate gravel layers, pale yellow brown - moist - pervious - dense - stones subrounded	(SP/GP)
3.0	9.0	Sand, pale brown - moist - pervious - dense - subrounded particles.	(SP)
9.0	13.0	Gravel, pale brown - moist - pervious - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(GP)

TP 10, 400' UPSTR., STA. C/L 13 + 00, ELEV. 813.9

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, yellow brown - moist - pervious - dense - 20% subrounded coarse gravel fragments.	(SP)
3.0	11.0	Sand, grayish white - moist - pervious - dense - 5% fine gravel.	(SP)
11.0	14.0	Silt, gray - wet - semipervious - dense - no gravels. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(ML)

TP 11, STA. A + 00, C/L 11 + 00, ELEV. 810.4

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	4.0	Sand, yellow brown - pervious - dense - moist - 10% stones 3-6" - 10% stones over 6" - 15% gravel.	(SP)
4.0	8.0	Sand, gray brown - moist - pervious - dense - 10% stones 3-6" - 20% stones over 6" - 5% gravel.	(SP)
8.0	14.0	Sand or gravel, olive gray - wet - pervious - dense - 5% stones 3-6" - 15% stones 6-12". WL @ 8.0' 5/21/63 Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP/GP)

TP 12, STA. C + 74, C/L 11 + 39, ELEV. 833.3

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, yellow brown - moist - pervious - dense - 10% gravel - subrounded particles.	(SP)
3.0	3.5	Sand, pale yellow brown - slightly moist - pervious - dense.	(SP)
3.5	5.0	Silt - moist - stiff - semipervious.	(ML)
5.0	5.5	Sand, pale gray - slightly moist - pervious - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP)

TP 13, STA. C/L + 44, C/L 9 + 48, ELEV. 823.3

From	To	Description	Class
0.0	1.0	Muck.	
1.0	6.0	Sand, gray - saturated - pervious - dense. Bottom of hole. Glaciofluvial material topped with recent alluvium. This hole could not be dug deeper because of sloughing and caving of the sides.	(SP)

AH 102, STA. C/L + 75, C/L 6 + 00, ELEV. 834.3

From	To	Description	Class
0.0	0.5	Topsoil.	
0.5	3.5	Sand, reddish brown - pervious - moist - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP)

TP 103, STA. 1100' DNSTR. OF C/L 5 + 50

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Silt, gray - moist - semipervious - slightly plastic - dense - no gravel or stones.	(ML)
3.0	4.0	Sand, reddish brown - moist - pervious - dense - 10% gravel.	(SP)
4.0	6.5	Sand, gray - moist - pervious - dense - 5% gravel - 5% stones over 3".	(SP)
6.5	7.5	Sand, reddish brown - moist - pervious - dense - 5% gravel - 10% stones over 3" - 2% stones over 6".	(SP)
7.5	14.0	Sand. Water seep at 12.0'. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP/SM)

TP 104, STA. 1000' DNSTR. OF C/L 6 + 00

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	6.5	Silt, gray - semipervious - slightly plastic - moist - firm - no gravel or stones.	(ML)
6.5	13.0	Sand, reddish brown to gray - moist - pervious to semipervious - dense - no gravel. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP)

TP 120, STA. 373' UPSTR. OF C/L 10 + 62, ELEV. 844.3

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	5.5	Sand, pale gray - moist - semipervious - dense - 15% gravel - 10% stones over 3".	(SM)
5.5	12.5	Sand, poorly graded, pale white gray - moist - pervious - dense - 10% gravel - 25% stones 3-6" - 10% stones 6-12". Entire hole 3% stones over 12". Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SP)

TP 121, STA. 460' UPSTR. OF C/L 11 + 25, ELEV. 836.3

From	To	Description	Class
0.0	1.0	Topsoil - occasional stones over 1 cubic yard on surface.	
1.0	3.0	Sand, silty, poorly graded, yellow brown - moist - pervious - dense - 10% stones over 6".	(SP/SM)
3.0	15.0	Gravel, poorly graded, brown to olive gray - moist to wet - semipervious to pervious - dense - 10-20% stones over 3". Bottom of hole. The entire profile is derived from glaciofluvial materials.	(GP/GM)

TP 130, STA. 1460' UPSTR. OF C/L 12 + 50, ELEV. 8?2.7

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	2.5	Sand, clean, yellow brown - moist - pervious - dense - no gravel or stones.	(SP)
2.5	10.0	Sand, clean, poorly graded, pale olive brown - moist - pervious - dense - 25% stones 3-6" - 10% stones over 6". Bottom of hole. Water in hole; material of glaciofluvial origin.	(SP)

TP 131, STA. 2200' UPSTR. OF C/L 10 + 90

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	2.0	Sand, silty, pale yellow brown - moist - semipervious - dense - 20% stones over 3".	(SM)
2.0	10.0	Gravel, clean, poorly graded, pale yellow brown - moist - pervious to semipervious - dense - 10% stones 3-6" - 25% stones 6-12". Bottom of hole.	(GP)

TP 201, STA. B + 96, C/L 7 + 25, ELEV. 850.2

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	4.0	Sand, clean, poorly graded, pale yellow brown - moist - pervious - dense.	(SP)
4.0	7.0	Gravel, clean, poorly graded, yellow brown - pervious - slightly moist - dense - 10% stones over 3".	(GP)
7.0	9.0	Sand, clean, well graded, yellow brown - coarse - slightly moist - pervious - dense. Bottom of hole. The entire profile is derived from glaciofluvial materials.	(SW)

TP 202, STA. B + 26, C/L 6 + 56, ELEV. 855.8

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	12.0	Gravel, clean, well graded, yellow brown - moist - dense - pervious. Bottom of hole. The entire profile derived from glaciofluvial materials.	(GW)

TP 203, STA. A + 31, C/L 5 + 84, ELEV. 862.0

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	4.0	Sand, clean, poorly graded, yellow brown - moist - pervious - dense.	(SP)
4.0	6.0	Gravel, clean, poorly graded, yellow brown - moist - pervious - dense.	(GP)
6.0	10.0	Sand, clean, poorly graded, yellow brown - pervious - moist - dense - no stones or gravel.	(SP)
10.0	13.0	Gravel, poorly graded - alternate SP & GP layers - moist - pervious - dense. Bottom of hole.	(GP)

AH 204, STA. B + 00, C/L 10 + 00, ELEV. 853.3
AH 205, STA. B + 50, C/L 9 + 00, ELEV. 843.2
AH 206, STA. B + 00, C/L 9 + 00, ELEV. 852.9
AH 207, STA. A + 50, C/L 9 + 00, ELEV. 857.5

From	To	Description	Class
0.0	1.5	Sand, clean, well graded, yellow brown - moist - pervious.	(SW)
1.5	1.8	Sand, poorly graded, yellow brown - slightly moist - dense - very pervious - 10% coarse gravel.	(SP)
1.8	3.0	Sand, clean, well graded, pale yellow brown - moist - pervious.	(SW)
3.0+		Sand, cobbly, clean, poorly graded, pale yellow brown - very pervious - dense. Bottom of hole. The entire profile derived from glaciofluvial materials.	(SP)

TP 401, STA. B + 21, C/L 10 + 55, ELEV. 825.0

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	3.0	Sand, clean, yellow brown to yellow color - moist - pervious - dense.	(SP)
3.0	5.0	Gravel, clean, poorly graded, pale olive - pervious - dense - 10% coarse gravel - 3% stones over 3".	(GP)
5.0	10.0	Sand, clean, poorly graded, olive - moist - pervious.	(SP)
10.0	13.0	Sand, clean, pale olive - no stones or gravel. Bottom of hole. The entire profile derived from glaciofluvial materials.	(SP)

TP 501, STA. C/L + 75, C/L 10 + 00, ELEV. 830.0

From	To	Description	Class
0.0	1.0	Topsoil.	
1.0	15.0	Gravel, well graded, olive brown - moist to wet - pervious - very dense - 15% stones over 3" - 5% stones over 12. Bottom of hole.	(GW)

TP 601, STA. ? + 27, C/L 1? + ??, ELEV. 8??.4

From	To	Description	Class
0.0	3.0	Muck.	
3.0	4.0	Gravel, clean, poorly graded, olive brown - wet - pervious - dense. WL 4.0' 5/21/63.	(GP)
4.0	10.0	Sand, clean, gray - pervious to semipervious - moist to wet - loose to firm density. Water boiling up near bottom of hole. Bottom of hole bedrock or large stones.	(SP)

LEGEND

TEST HOLE NUMBERING SYSTEM

Centerline of dam	1 - 99
Borrow area	101 - 199
Emergency spillway	201 - 299
Centerline of outlet structure	301 - 399
Stream channel	401 - 499
Relief wells	501 - 599
	601 - 699
	701 - 799

UNIFIED SOIL CLASSIFICATION SYSTEM SYMBOLS

GW	Well graded gravels; gravel-sand mixtures
GP	Poorly graded gravels
GM	Silty gravels; gravel-sand-silt mixtures
GC	Clayey gravels; gravel-sand-clay mixtures
SW	Well graded sands; sand-gravel mixtures
SP	Poorly graded sands
SM	Silty sands; sand-silt mixtures
SC	Clayey sands; sand-clay mixtures
ML	Silts; silty, v. fine sands; sandy or clayey silts
CL	Clays of low to medium plasticity; silty, sandy or gravelly clays
CH	Clays of high plasticity; fat clays
MH	Elastic silts; micaceous or diatomaceous silts
OL	Organic silts and organic silty clays of low plasticity
OH	Organic clays or silts of medium to high plasticity

BEDROCK SYMBOLS

Di	Diorite	Sc	Schist
Gn	Gneiss	Hs	Shale
Gr	Granite	Si	Siltstone
Ls	Limestone	Sl	Slate
Ma	Marble	Ss	Sandstone

SAMPLES

DS Disturbed
US Undisturbed

ABBREVIATIONS

PP Pocket Penetrometer Readings
AH Auger Hole

KEY TO DRILL HOLE (DH) LOGS

N = 4 — N - Number of blows required for 1 ft. standard penetration, using 2.0" O.D. split barrel sampler, 140 lb. hammer, and 30" drop. ASTM D 1586
10 — 5.0 Depth in hole (ft.)
SP-Unified Soil Classification Symbol
10.0
SP-
16.5 Depth in hole (ft.)
NX - Rock core, 2-1/8" diameter
88% Percent rock core recovery in each drill run
Di-Bedrock symbol

▼ WL (date) Water Level

Vertical scale 1" = 10'

All soil and rock descriptions and classifications were determined by visual examination.

Location of test holes are shown on sheets.

(plans, profiles, sections)

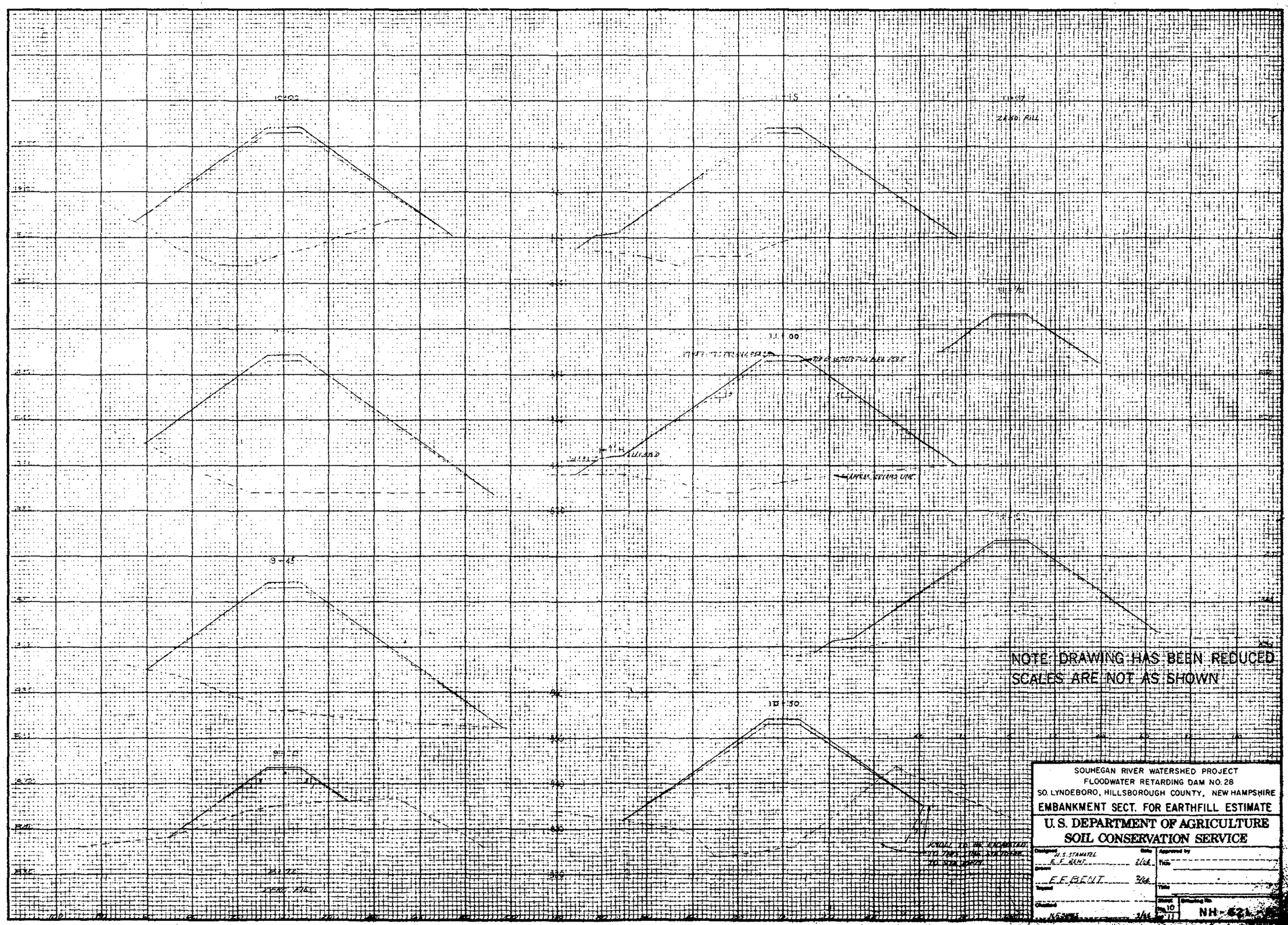
NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN

SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 28
SO. LYNDEBORO, HILLSBOROUGH COUNTY, NEW HAMPSHIRE

LOGS OF TEST HOLES

U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Investigated by Richard Bond	Date	Approved by	
Typed by A.F. Morell		Title	
Drawn		Title	
Checked M.K. Shires		Sheet No. 7 of 11	Drawing No NH-621-P


NOTE: DRAWING HAS BEEN REDUCED
SCALES ARE NOT AS SHOWN
SOUHEGAN RIVER WATERSHED PROJECT
FLOODWATER RETARDING DAM NO. 28
SO. LYNDEBORO, HILLSBOROUGH COUNTY, NEW HAMPSHIRE
EMBANKMENT SECT. FOR EARTHFILL ESTIMATE
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
NH-621

The U.S.D.A. Soil Conservation Service (SCS) located in Durham, New Hampshire, maintains a file for this dam. Included in this file are:

1) SCS "Design Report" dated June 1964.

2) SCS "Hydrology and Hydraulics" design calculations dated 1963.

3) SCS structural design calculations dated 1964.

4) SCS "Detailed Geological Investigation of Dam Sites" dated 1963.

5) SCS soil mechanics laboratory data sheets dated November 1963.

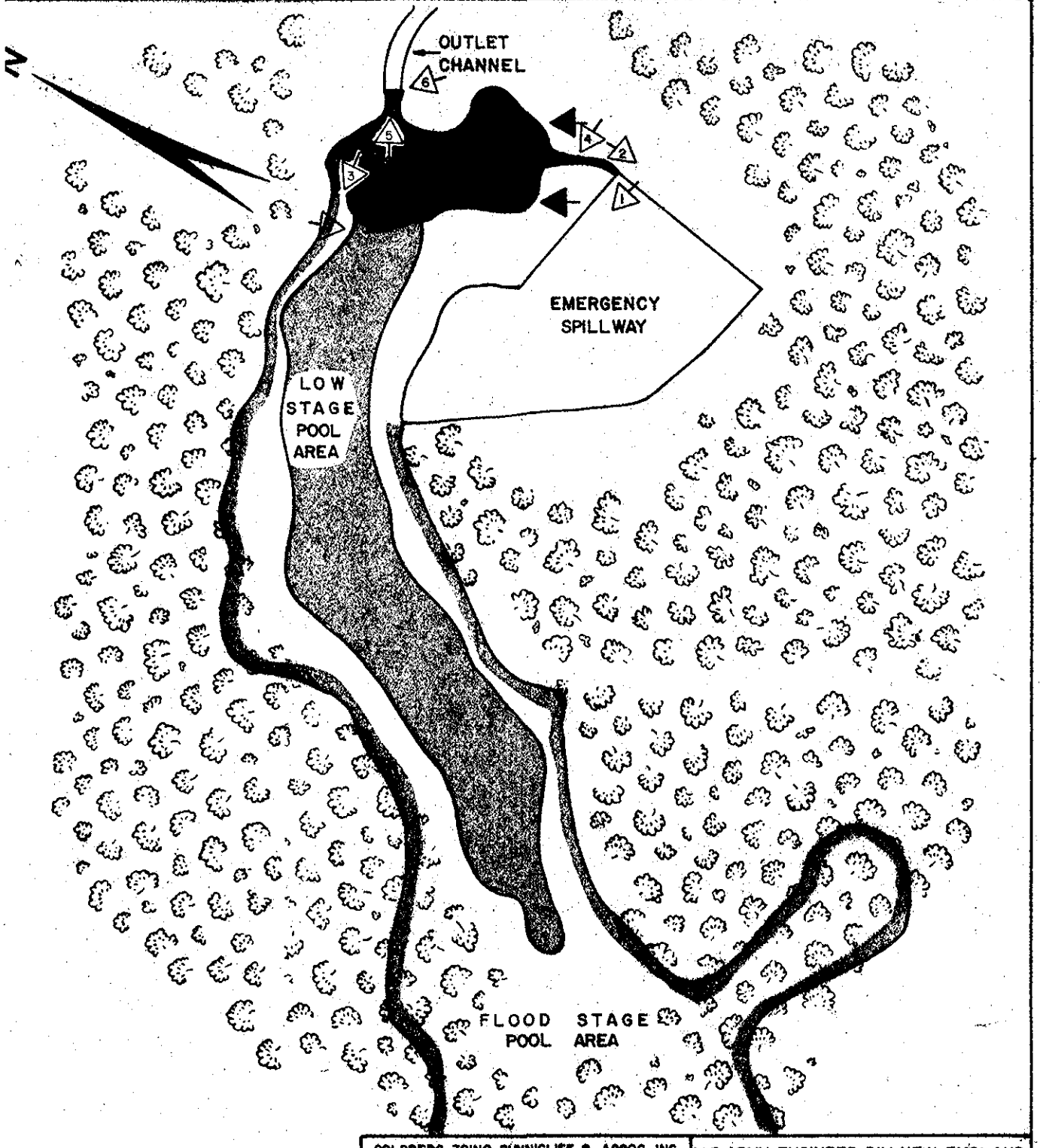
6) SCS "As Built" drawings undated.

The New Hampshire Water Resources Board (NHWRB) maintains a correspondence file on this dam. Included in this file are:

1) Maintenance inspection checklists dated June 2, 1972 and June 15, 1978.

APPENDIX C

PHOTOGRAPHS



GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

OVERVIEW

APPENDIX C

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION AND ORIENTATION OF PHOTOS

SOUHEGAN RIVER WATERSHED

DAM No. 28 NEW HAMPSHIRE

FILE No. 2327

SCALE 1" = 200'

DATE MAY 1979

1. View of emergency spillway channel looking upstream

2. View of downstream end of emergency spillway showing rock dump fill and tree growth

3. View of left upstream reservoir slope showing debris and recent sloughing

4. View of animal burrow in right downstream slope near the end of the embankment

5. View of downstream channel showing plunge pool and riprap protection

6. View of outlet pipe and right toe drain outlet

7. View of bench stand on submerged inlet structure

APPENDIX D

HYDROLOGIC/HYDRAULIC COMPUTATIONS

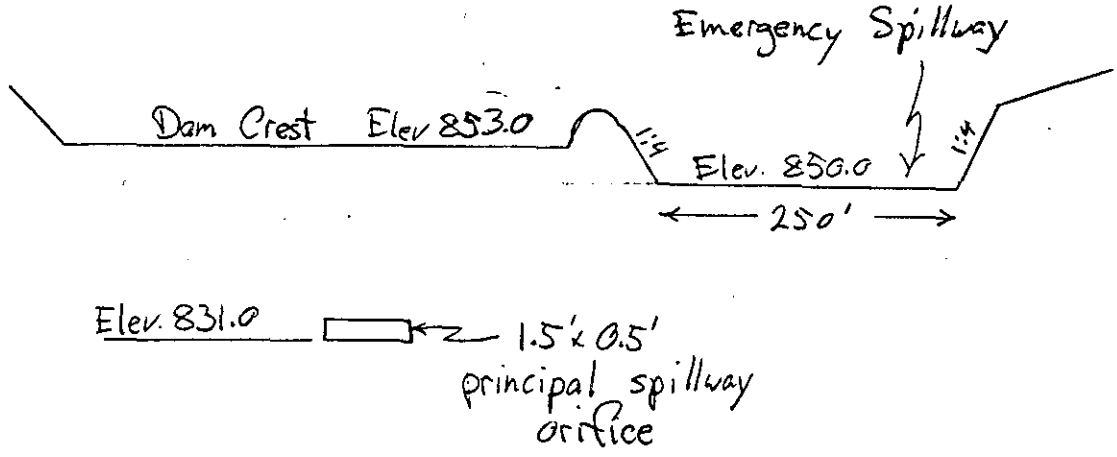
Dam Rating Curve

The principal spillway consists of a riser which reservoir discharges enter through an orifice and which is drained by a 186' long 30"ϕ RC pipe. It is designed such that the flow rate is controlled by the orifice rather than by the drain pipe.

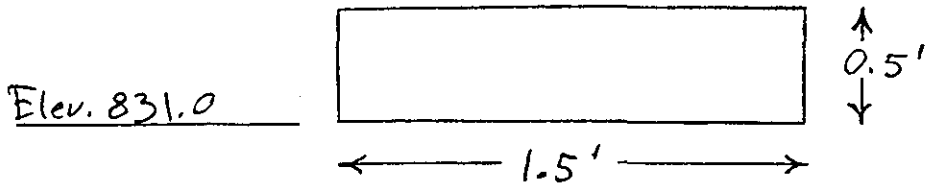
The emergency spillway is a grass-lined channel at the end of which is a critical flow control section.

The stage-discharge (rating) function for the two outlets has been computed by the SCS as part of the design calculations. A summary of these calculations follows.

Schematic Section of Dam
No Scale



Principal Spillway Orifice



Datum -- Elev. 831.0

$H = 0$ to $H = 0.5'$

$Q = C L H^{3/2}$

$C = 3.4$

$L = 1.75'$ (This disagrees with the final design value of 1.5', but the difference is not significant in terms of the ability of the dam to pass a major flood)

$Q = 5.95 H^{3/2}$

$H > 1.0$

$Q = C A \sqrt{2g \times H_{orifice}}$

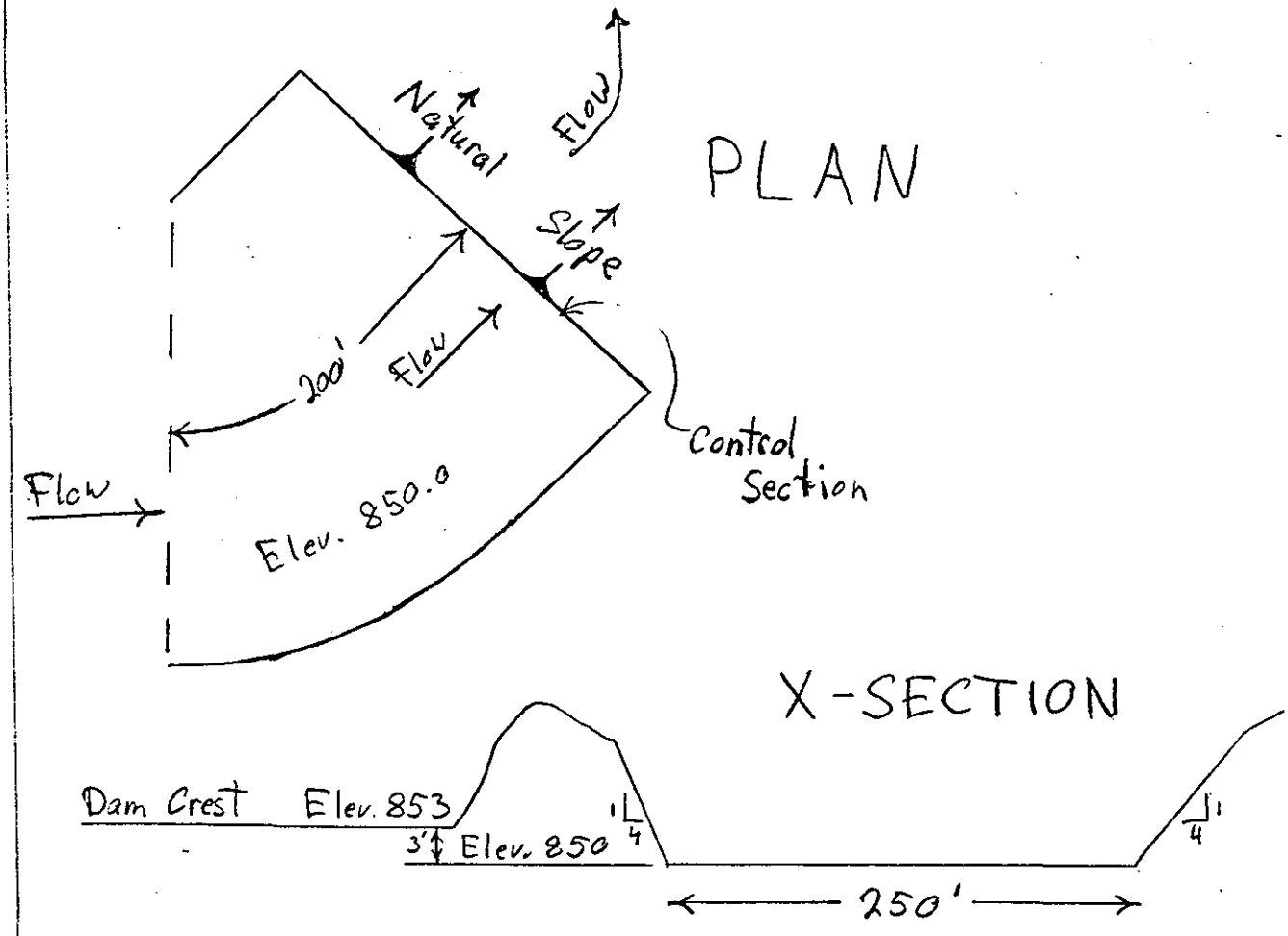
$C = 0.65$

$A = 0.875\ ^{12}$ (See note for L above)

$H_{orifice} = H - 0.25$

$Q = 4.56 (H - 0.25)^{1/2}$

Emergency Spillway



Weir flow is assumed at the control section. For a given discharge, the H at the control section must be adjusted by a backwater computation to determine the water surface elev. of the reservoir 200' u/s.

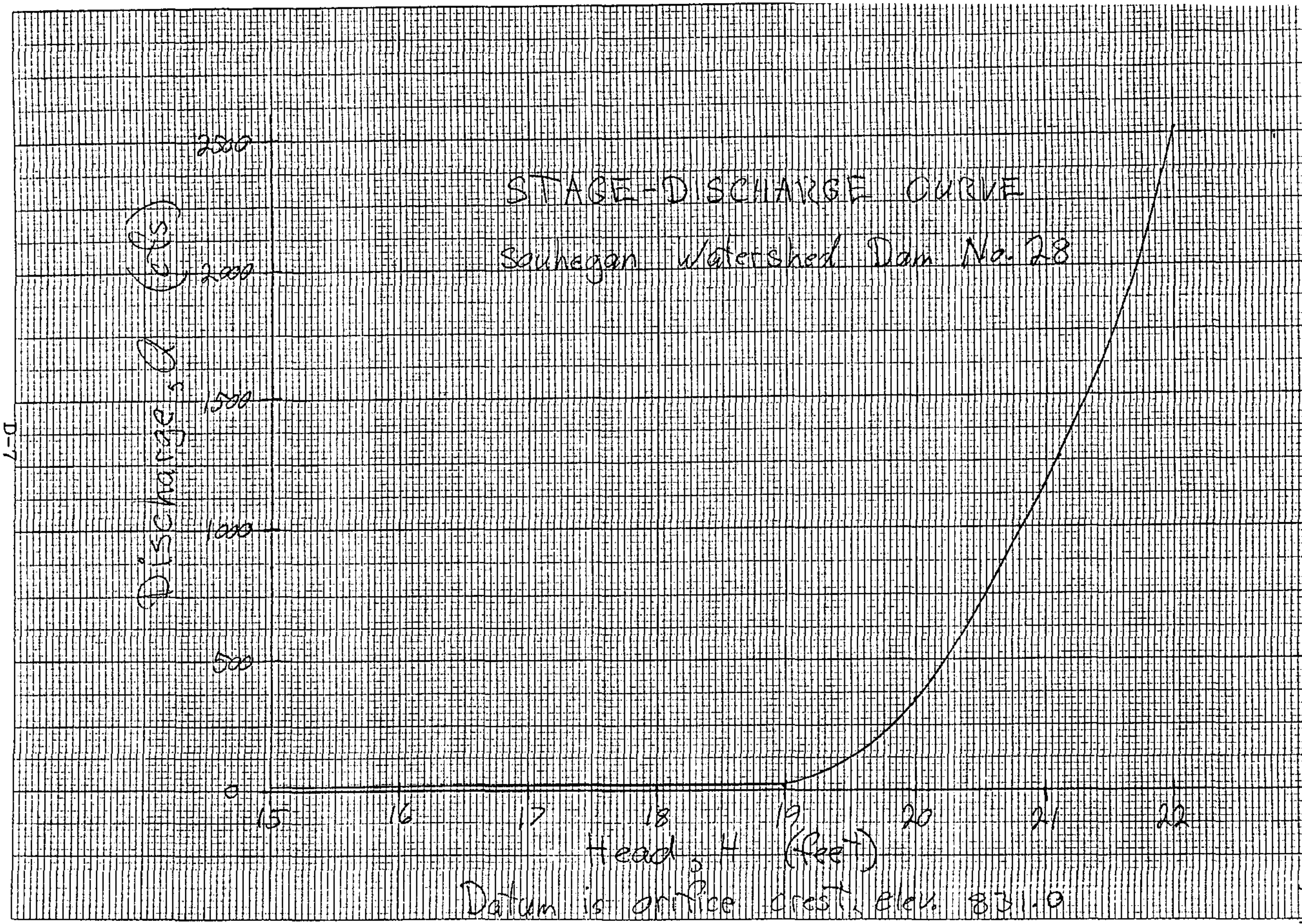
These computations were made with the use of SCS ES 124, sheet 18 with L=200' (channel length, b=250' (channel bottom width), and z=4 (side-slopes)

Rating Table

from sheet 4-5 of SCS design calcs.

Pool Elev.	H	Q
831.0	0	0
836.0	5	10
840.0	9	14.
846.0	15	18.
850.0	19	20
850.96	19.96	270
852.09	21.09	1271
853.0	22	2521

This table includes the combined emergency spillway and principal spillway outflows.



STAGE-DISCHARGE CURVE
Souhegan Watershed Dam No. 28
Discharge, Q (cfs)
2500
2000
1500
1000
500
0
15
16
17
18
19
20
21
22
Head, H (feet)
Datum is orifice crest, elev. 831.0

Stage - Storage Function

A copy of the stage - storage and stage - surface area curves computed and drawn by the SCS as part of the design calculations is included on the next page.

The flood storage to the emergency spillway level is 186.9 acre-ft

Drainage Area

608 acres

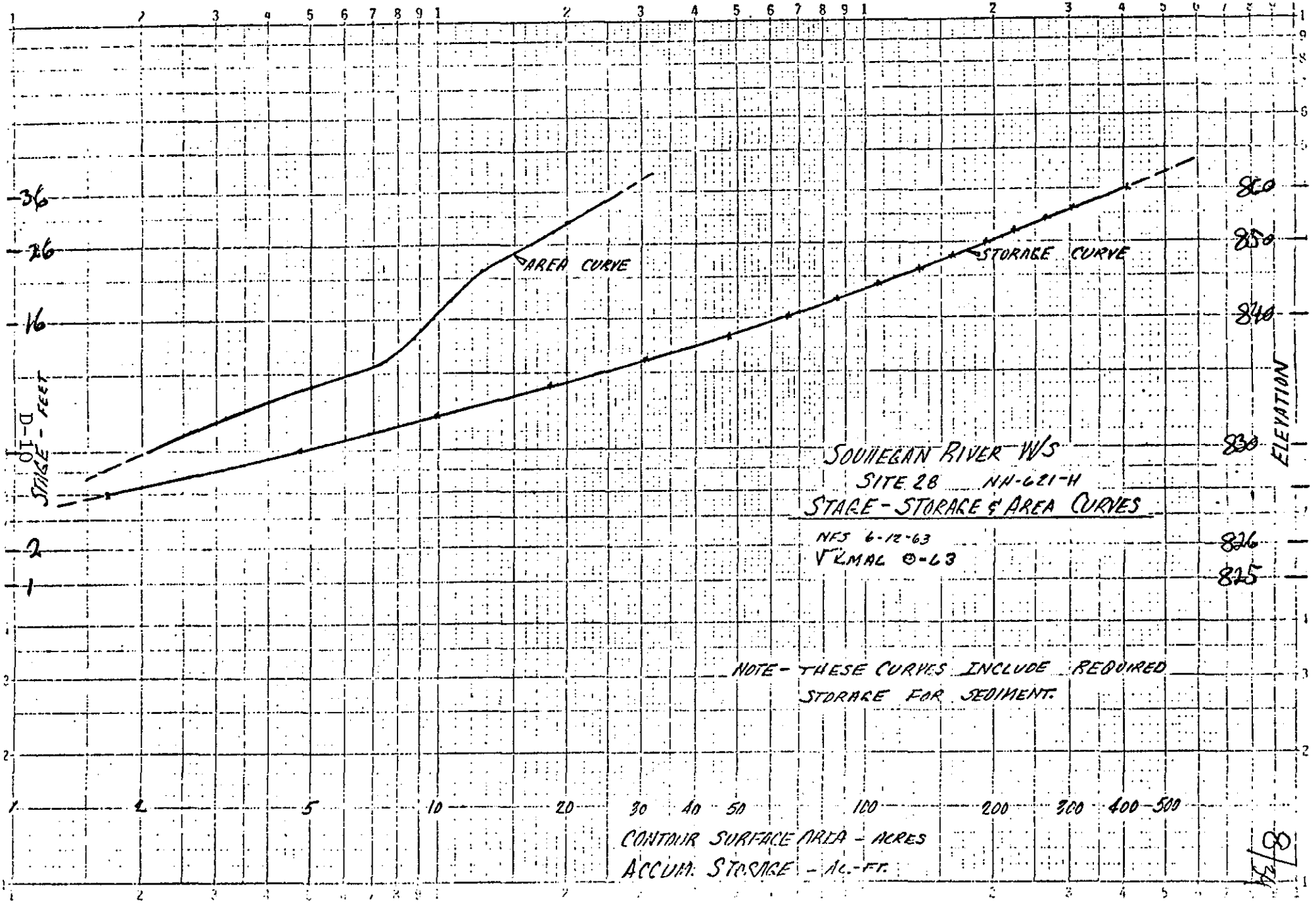
$$\text{Storage} = \frac{187}{608} \times 12 = 3.7'' \text{ runoff}$$

Flood storage to the top of dam is 263 acre-ft

$$\text{Storage} = \frac{263}{608} \times 12 = 5.2'' \text{ runoff}.$$

Stage - Storage Table

Pool Elev.	Area (acres)	Vol. (acre-ft)
824	0	0
828	.9	1.7
832	3.2	9.9
836	7.6	30.7
840	9.6	65.4
844	11.6	108.
848	14.5	159
850	16.5	190
852	18.3	225
853	20.0	263


AREA CURVE
STORAGE CURVE
STAGE - FEET
ELEVATION
36
26
16
2
1
850
840
830
826
825
SOUHEGAN RIVER W/S
SITE 28 NH-621-H
STAGE-STORAGE & AREA CURVES
NFS 6-12-63
VERMAC 0-63
NOTE- THESE CURVES INCLUDE REQUIRED STORAGE FOR SEDIMENT.
1 2 5 10 20 30 40 50 100 200 300 400 500
CONTOUR SURFACE AREA - ACRES
ACCUM. STORAGE - AC.-FT.
D-10
8/24

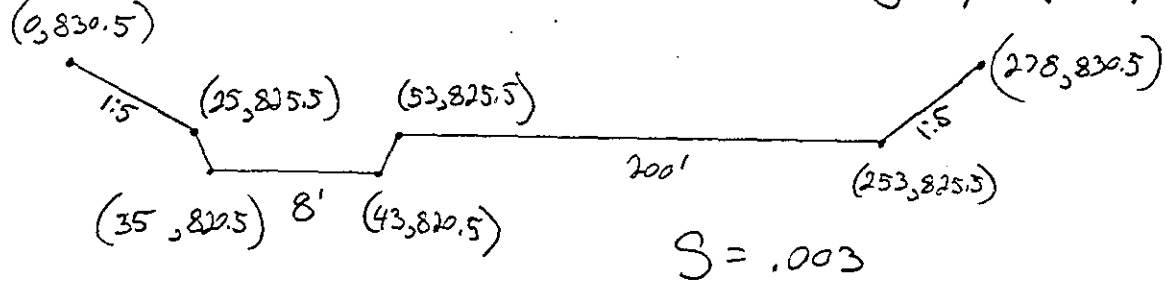
Dam Failure Analysis

Outflow at Failure = Outflow through breach
+ Normal outflow at failure elev. of pool

Assume that the dam fails when it is overtopped with the pool at the level of the dam crest
-- elev. 853.0

Normal Outflow
Q = 2520 cfs (dam rating curve with H=22')

Tailwater level at failure
Estimate with normal flow rating for the excavated channel just below the dam. Emergency spillway



S = .003
n = .04

discharge will return to this channel.
Rating table is shown on the next page.

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	820.5	0.0	0.0	0.0	0.0	0.0
0.5	821.0	4.5	10.2	0.4	2.6	5.3
1.0	821.5	10.0	12.5	0.8	8.6	17.6
1.5	822.0	16.5	14.7	1.1	17.8	36.3
2.0	822.5	24.0	16.9	1.4	30.3	61.8
2.5	823.0	32.5	19.2	1.7	46.2	94.3
3.0	823.5	42.0	21.4	2.0	65.8	134.3
3.5	824.0	52.5	23.7	2.2	89.4	182.3
4.0	824.5	64.0	25.9	2.5	117.0	238.8
4.5	825.0	76.5	28.1	2.7	149.1	304.2
5.0	825.5	90.0	30.4	3.0	185.8	379.1
5.5	826.0	205.3	235.5	0.9	187.3	382.1
6.0	826.5	323.0	240.6	1.3	393.2	802.1
6.5	827.0	443.3	245.7	1.8	657.1	1340.6
7.0	827.5	566.0	250.8	2.3	974.2	1987.6
7.5	828.0	691.3	255.9	2.7	1341.3	2736.7
8.0	828.5	819.0	261.0	3.1	1756.3	3583.3
8.5	829.0	949.3	266.1	3.6	2217.4	4524.0
9.0	829.5	1082.0	271.2	4.0	2723.3	5556.4
9.5	830.0	1217.3	276.3	4.4	3273.2	6678.3
10.0	830.5	1355.0	281.4	4.8	3866.3	7888.3

CHANNEL RATING IMMEDIATELY D/S OF S.W.D. #28

10/34

$Q = 2520$ cfs $\Rightarrow$ Tailwater elev. $\cong 827.8$

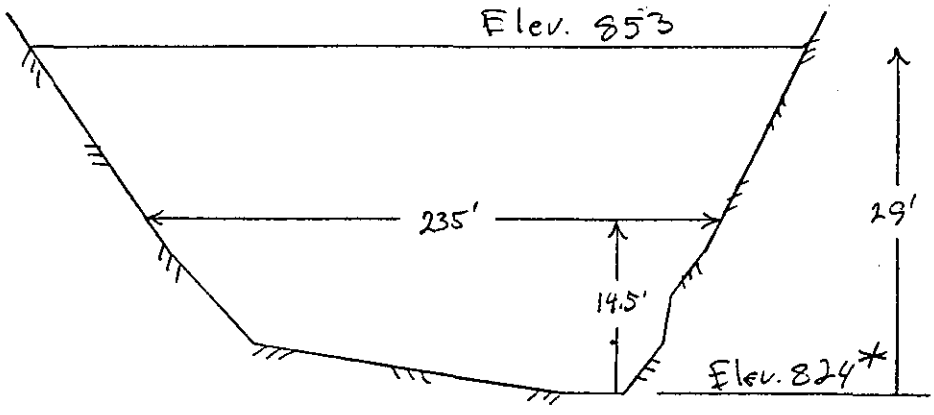
Breach Outflow

$$Q_{p1} = 8/27 * W_b \times \sqrt{g} \times Y_o^{3/2}$$

W_b = width of breach

$\leq 0.4 \times$ (width of dam at 1/2 height)

use $W_b = 0.4 \times 235 = 94'$



* This is the natural streambed level at the dam.

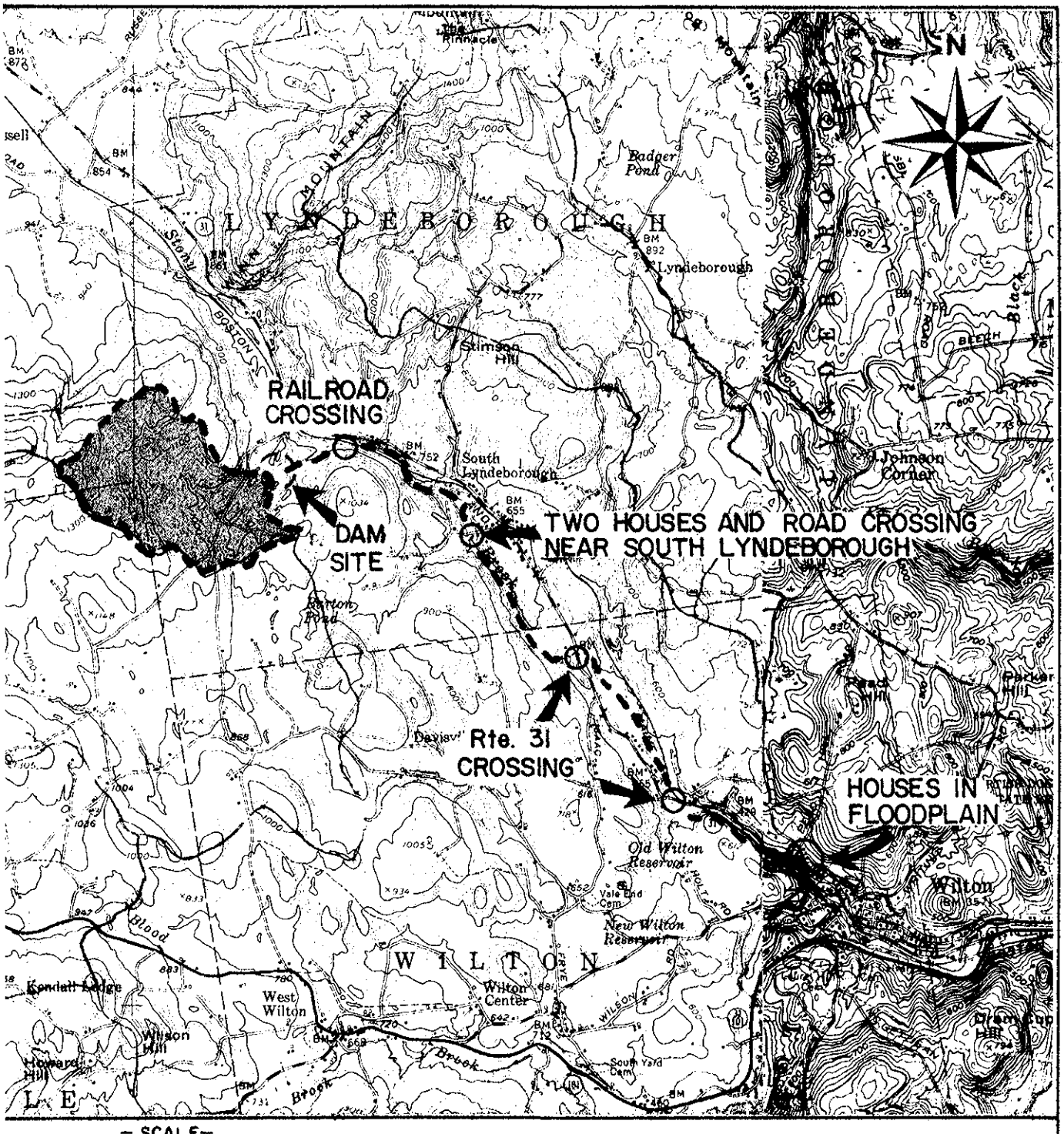
Y_o = pool elev. − tailwater elev.

$= 853 - 827.8 = 25.2'$

$$Q_{p1} = 8/27 \times 94 \times \sqrt{g} \times 25.2^{3/2} = 20{,}000 \text{ cfs}$$

Total Outflow

$$Q_{tot} = 20000 + 2500 = \underline{\underline{22500}} \text{ cfs}$$



— SCALE —

0 1/2 1 2 (Miles)

FROM: USGS MILFORD AND PETERBOROUGH – N.H. QUADRANGLE MAPS.

GOLDBERG, ZOINO, DUNNICLIFF & ASSOC., INC.
GEOTECHNICAL CONSULTANTS
NEWTON UPPER FALLS, MASS.

U.S. ARMY ENGINEER DIV. NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

NATIONAL PROGRAM OF INSPECTION OF NON-FED. DAMS

LOCATION MAP

FILE No. 2327

SOUHEGAN RIVER
WATERSHED DAM No. 28 LYNDEBOROUGH, NEW HAMPSHIRE

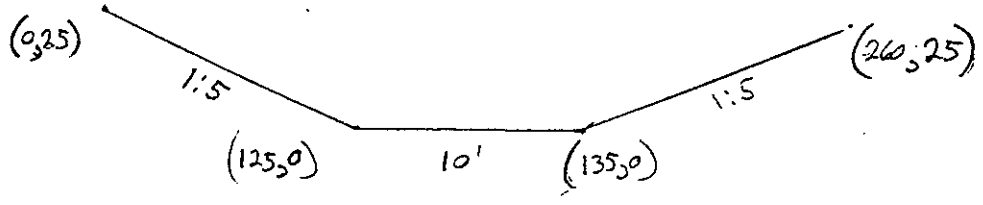
SCALE AS NOTED

DATE

Downstream Flooding

Tributary to Stony Brook d/s of SWD #28

S = .02
n = .04



The section shown above is typical for the reach from the dam 0.5 mile d/s to the confluence with Stony Brook.

Estimate peak dam break flow 0.5 mile d/s of dam

Follow (essentially) COE "'Rule of Thumb' Guidance for Estimating Downstream Dam Failure Hydrographs"

A simple BASIC program was used to calculate a rating table for this reach (next page) based on the representative section sketched above.

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	15.0	20.2	0.7	12.3	64.8
2.0	2.0	40.0	30.4	1.3	48.0	253.1
3.0	3.0	75.0	40.6	1.8	112.9	595.0
4.0	4.0	120.0	50.8	2.4	212.9	1121.7
5.0	5.0	175.0	61.0	2.9	353.5	1862.2
6.0	6.0	240.0	71.2	3.4	539.8	2843.8
7.0	7.0	315.0	81.4	3.9	776.9	4092.5
8.0	8.0	400.0	91.6	4.4	1069.3	5633.0
9.0	9.0	495.0	101.8	4.9	1421.6	7489.1
10.0	10.0	600.0	112.0	5.4	1838.2	9683.7
11.0	11.0	715.0	122.2	5.9	2323.3	12238.9
12.0	12.0	840.0	132.4	6.3	2880.9	15176.3
13.0	13.0	975.0	142.6	6.8	3515.0	18516.8
14.0	14.0	1120.0	152.8	7.3	4229.5	22280.7
15.0	15.0	1275.0	163.0	7.8	5028.2	26488.0
16.0	16.0	1440.0	173.2	8.3	5914.7	31158.2
17.0	17.0	1615.0	183.4	8.8	6892.7	36310.3
18.0	18.0	1800.0	193.6	9.3	7965.7	41963.1
19.0	19.0	1995.0	203.8	9.8	9137.3	48134.9
20.0	20.0	2200.0	214.0	10.3	10410.8	54843.7
21.0	21.0	2415.0	224.2	10.8	11789.7	62107.4
22.0	22.0	2640.0	234.4	11.3	13277.2	69943.4
23.0	23.0	2875.0	244.6	11.8	14876.6	78368.9
24.0	24.0	3120.0	254.8	12.2	16591.1	87400.8
25.0	25.0	3375.0	265.0	12.7	18423.9	97056.0

TRIBUTARY TO STONY BROOK D/S OF S.W.D. #28

Storage in Reach vs. Outflow (Q_{p2})

Assume channel storage equal to average of u/s flow area (known) and d/s flow area (function of reach outflow) times the reach length.

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = .5 \times 5280 = 2640'$

$A_1 = 1130'^2$ (from stream rating with $Q_{p1} = 22500$ cfs)

$A_2 = f(Q_{p2})$ (use stream rating table)

Channel Storage vs. Outflow

Q_{p2}	D_2	A_2	Vol
12240 cfs	11'	$715'^2$	57.5 acre-ft.
15180	12'	840	61.4
18520	13'	975	65.6
22280	14	1120	70.1

Peak Outflow from Reach

$$Q_{p2} = Q_{p1}\left(1 - \frac{Vol}{S}\right)$$

$Q_{p1} = 22500$ cfs

$S = 263$ acre-ft (Volume behind dam, see Stage-Storage curve)

$$Q_{p2} = 22500\left(1 - \frac{Vol}{263}\right)$$

$$Vol = 263\left(1 - \frac{Q_{p2}}{22500}\right)$$

guess $Q_{p2} = 15000$ cfs

$$\Rightarrow Vol = 263\left(1 - \frac{15000}{22500}\right) = 87.7$$

$$\Rightarrow Q_{p2} > 15000$$

use → guess $Q_{p2} = \underline{17,000 \text{ cfs}}$

$$\Rightarrow Vol = 64.3 \text{ acre-ft} \quad \text{OK}$$

Depth of flow

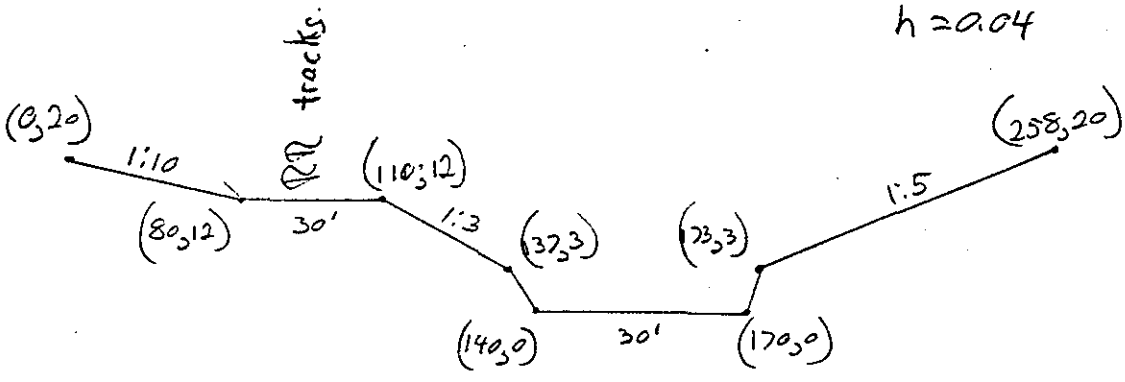
prior to dam failure $\cong 5.7'$

after dam failure $\cong \underline{12.5'}$

Estimate Depth of Flow in Stony Br. at confluence with tributary

$S = 0.015$

$h = 0.04$



A_n normal flow rating table for Stony Br. at this point, based on the approximate section sketched above, is shown on the next page.

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	31.0	32.8	0.9	29.8	136.1
2.0	2.0	64.0	35.7	1.8	94.5	431.3
3.0	3.0	99.0	38.5	2.6	185.9	848.2
4.0	4.0	139.0	46.7	3.0	287.5	1311.8
5.0	5.0	187.0	55.0	3.4	423.0	1929.6
6.0	6.0	243.0	63.3	3.8	596.2	2720.1
7.0	7.0	307.0	71.5	4.3	811.2	3700.7
8.0	8.0	379.0	79.8	4.7	1071.5	4888.3
9.0	9.0	459.0	88.1	5.2	1380.7	6299.0
10.0	10.0	547.0	96.3	5.7	1742.2	7948.3
11.0	11.0	643.0	104.6	6.1	2159.4	9851.4
12.0	12.0	747.0	112.8	6.6	2635.4	12023.0
13.0	13.0	892.5	158.0	5.6	2832.6	12922.8
14.0	14.0	1053.0	173.1	6.1	3510.6	16016.1
15.0	15.0	1228.5	188.3	6.5	4292.3	19582.1
16.0	16.0	1419.0	203.4	7.0	5183.7	23648.9
17.0	17.0	1624.5	218.6	7.4	6190.8	28243.6
18.0	18.0	1845.0	233.7	7.9	7319.5	33393.0
19.0	19.0	2080.5	248.9	8.4	8575.5	39123.1
20.0	20.0	2331.0	264.0	8.8	9964.4	45459.5

STREAM RATING STONY BROOK AT CONFLUENCE W/ TRIBUTARY

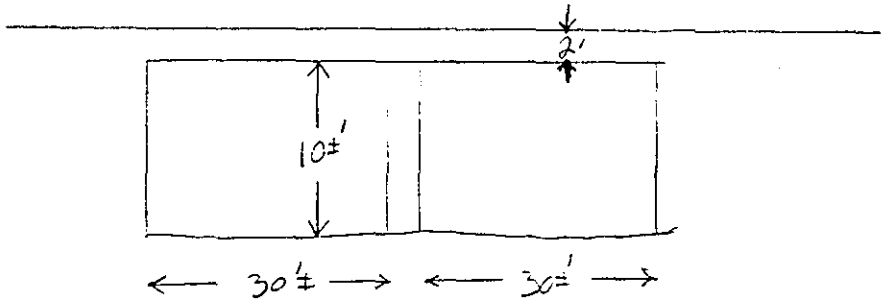
16/34

from Rating Table,

$Q = 17000$ cfs

$\Rightarrow$ depth of flow > 14'

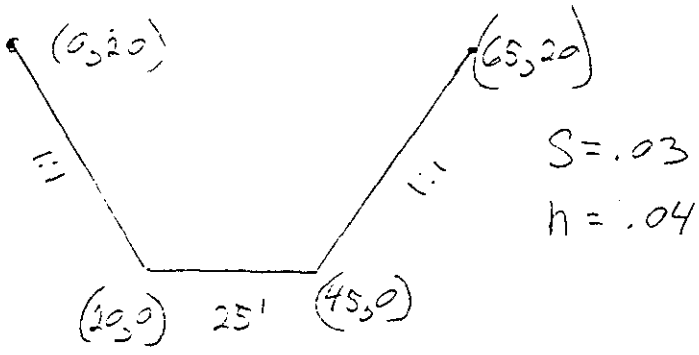
Railroad bridge 200± d/s of confluence



The estimated peak dam failure flow depth of 14' would probably damage the railroad bridge and roadbed.

Estimate Peak Dam Break Flow in Stony Br. outside of S: Lyndeborough 1.5 mile d/s of dam

Typical Section of Stony Br. for this reach



a rating table based on this sketch is shown on the following page

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = 5280'$

$A_1 = 610'^2$ (from rating table w/ $Q = 13{,}000$)

$A_2 = f(Q_{p2})$

Q_{p2}	D_2	A_2	Vol
11,900 cfs	12'	$444'^2$	65.7 acre-ft.
12800	13'	494	68.8
14600	14'	546	72.1
16600	15'	600	75.4

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	26.0	27.8	0.9	24.8	160.3
2.0	2.0	54.0	30.7	1.8	78.8	508.2
3.0	3.0	84.0	33.5	2.5	155.1	1000.9
4.0	4.0	116.0	36.3	3.2	251.7	1623.9
5.0	5.0	150.0	39.1	3.8	367.5	2371.0
6.0	6.0	186.0	42.0	4.4	502.1	3239.4
7.0	7.0	224.0	44.8	5.0	655.3	4228.2
8.0	8.0	264.0	47.6	5.5	827.3	5337.9
9.0	9.0	306.0	50.5	6.1	1018.3	6569.7
10.0	10.0	350.0	53.3	6.6	1228.3	7925.1
11.0	11.0	396.0	56.1	7.1	1457.9	9406.3
12.0	12.0	444.0	58.9	7.5	1707.3	11015.5
13.0	13.0	494.0	61.8	8.0	1977.0	12755.1
14.0	14.0	546.0	64.6	8.5	2267.2	14627.5
15.0	15.0	600.0	67.4	8.9	2578.4	16635.5
16.0	16.0	656.0	70.3	9.3	2911.0	18781.6
17.0	17.0	714.0	73.1	9.8	3265.5	21068.6
18.0	18.0	774.0	75.9	10.2	3642.2	23499.2
19.0	19.0	836.0	78.7	10.6	4041.6	26076.1
20.0	20.0	900.0	81.6	11.0	4464.1	28802.1

STREAM RATING STONY BROOK U/S OF SOUTH LYNDEBOROUGH

19/24

$$Vol = 263\left(1 - \frac{Qp2}{17000}\right)$$

guess $Q_{p2} = 14000$ cfs $\Rightarrow Vol = 46.4$ acre-ft.

guess $Q_{p2} = 13000$ cfs $\Rightarrow Vol = 61.5$

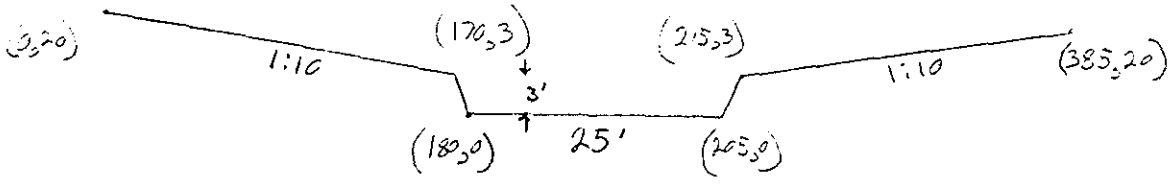
guess $Q_{p2} = 12500$ cfs $\Rightarrow Vol = 69.6$

use $Q_{p2} = 12800$ cfs

Estimate Depth of Flooding at South Lyndeborough

Stony Brook at South Lyndeborough village, 1.6 miles d/s of SWD 28

S = .015
n = .04



A rating table for the section sketched above is shown on the following page.

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	28.3	32.0	0.9	26.1	119.3
2.0	2.0	63.3	38.9	1.6	87.6	399.8
3.0	3.0	105.0	45.9	2.3	182.4	832.1
4.0	4.0	160.0	66.0	2.4	288.9	1317.9
5.0	5.0	235.0	86.1	2.7	459.2	2094.9
6.0	6.0	330.0	106.2	3.1	703.1	3207.5
7.0	7.0	445.0	126.3	3.5	1030.9	4703.3
8.0	8.0	580.0	146.4	4.0	1453.0	6628.7
9.0	9.0	735.0	166.5	4.4	1979.0	9028.7
10.0	10.0	910.0	186.6	4.9	2618.5	11946.2
11.0	11.0	1105.0	206.7	5.3	3380.5	15422.5
12.0	12.0	1320.0	226.8	5.8	4273.8	19497.7
13.0	13.0	1555.0	246.9	6.3	5306.8	24210.3
14.0	14.0	1810.0	267.0	6.8	6487.7	29598.0
15.0	15.0	2085.0	287.1	7.3	7824.6	35697.4
16.0	16.0	2380.0	307.2	7.7	9325.4	42543.9
17.0	17.0	2695.0	327.3	8.2	10997.5	50172.4
18.0	18.0	3030.0	347.4	8.7	12848.4	58616.9
19.0	19.0	3385.0	367.5	9.2	14885.6	67910.7
20.0	20.0	3760.0	387.6	9.7	17116.1	78086.5

STONY BROOK AT SOUTH LYNDEBOROUGH VILLAGE

In the vicinity of S. Lyndeborough Village there are 2 houses, each with first floor levels approximately 15' above the stream bed.

Dam break discharge

$Q_p \cong 12800$ cfs

Depth $\cong 10.5'$ houses ok

Add, say, a 10 year flow in Stony Br. from other sources

$Q_{10\,yr.} \cong 2900$ cfs

(This is FIS value for a reach of Stony Br. ~3 miles d/s of this point. It is thus probably an over-estimate.)

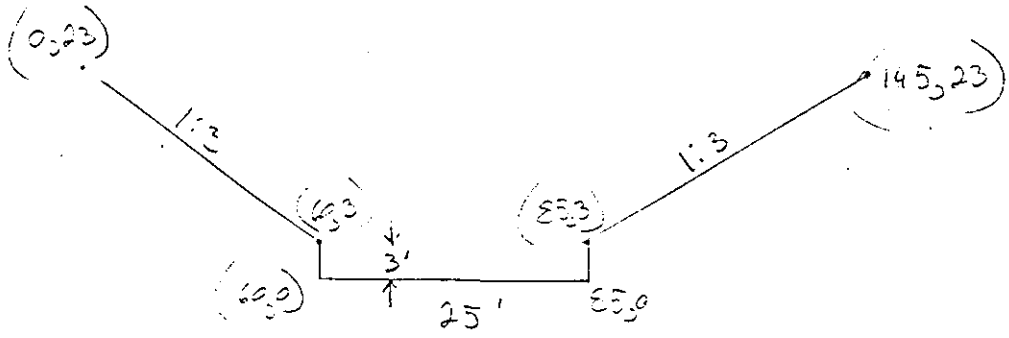
$Q_{tot} = Q_p + Q_{10yr.} = 15{,}700$ cfs

Depth $\cong 11.1'$ houses ok

Estimate Peak Dam Break Flow 2.5 miles d/s of dam

Typical Section of Stony Br.
1.6 to 2.5 miles d/s of SWD #28

S = .02
n = .04



A rating table based on this sketch is shown on the following page

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = .9 \times 5280 = 4750$

$A_1 = 670'^2$ (from rating table w/ Q = 12800)

$A_2 = f(Q_{p2})$

Q_{p2}	D_2	A_2	Vol
6340	9.0	397	59.9
7876	10.0	467	63.8
9634	11.0	543	68.1
11629	12.0	625	72.7
12800	12.5	670	75.2

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	25.0	27.0	0.9	23.7	125.1
2.0	2.0	50.0	29.0	1.7	71.9	378.8
3.0	3.0	75.0	31.0	2.4	135.2	712.2
4.0	4.0	103.0	37.3	2.8	202.7	1067.9
5.0	5.0	137.0	43.6	3.1	293.8	1547.7
6.0	6.0	177.0	50.0	3.5	411.4	2167.5
7.0	7.0	223.0	56.3	4.0	558.5	2942.3
8.0	8.0	275.0	62.6	4.4	737.8	3886.8
9.0	9.0	333.0	68.9	4.8	952.0	5014.9
10.0	10.0	397.0	75.3	5.3	1203.6	6340.3
11.0	11.0	467.0	81.6	5.7	1495.1	7876.0
12.0	12.0	543.0	87.9	6.2	1828.9	9634.8
13.0	13.0	625.0	94.2	6.6	2207.5	11629.0
14.0	14.0	713.0	100.6	7.1	2633.0	13870.6
15.0	15.0	807.0	106.9	7.5	3107.7	16371.4
16.0	16.0	907.0	113.2	8.0	3633.8	19142.9
17.0	17.0	1013.0	119.5	8.5	4213.5	22196.4
18.0	18.0	1125.0	125.9	8.9	4848.7	25542.8
19.0	19.0	1243.0	132.2	9.4	5541.6	29193.0
20.0	20.0	1367.0	138.5	9.9	6294.2	33157.7
21.0	21.0	1497.0	144.8	10.3	7108.5	37447.2
22.0	22.0	1633.0	151.2	10.8	7986.4	42071.9
23.0	23.0	1775.0	157.5	11.3	8929.8	47041.9

STREAM RATING STONY BROOK D/S OF S.W.D. #28 (1.6 TO 2.5 MI.)

$$Vol = 263\left(1 - \frac{Q_{p2}}{12800}\right)$$

guess $Q_{p2} = 10000 \Rightarrow Vol = 57.5$

$8000 \quad 98.6$

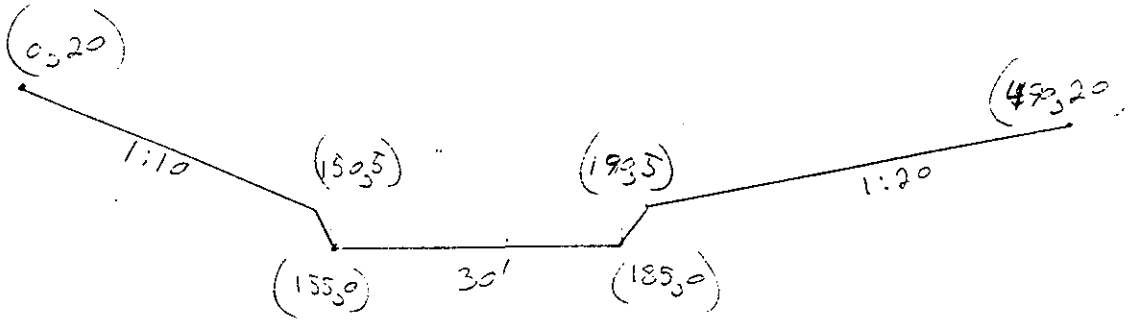
use $Q_{p2} = 9500 \quad 67.8$

Depth of Flow $\cong 12.0'$

Estimate Peak Flow 4.0 miles d/s of dam

Typical Section of Stony Brook
2.5 to 4.0 miles d/s of SWD #28

$S = 0.01$
$n = 0.04$



A rating table based on this sketch is shown on the following page

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = 1.5 \times 5280$
$A_1 = 965$ (from rating table of $Q = 9500$)

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	1.0	31.0	32.8	0.9	29.8	111.1
2.0	2.0	64.0	35.7	1.8	94.5	352.2
3.0	3.0	99.0	38.5	2.6	185.9	692.6
4.0	4.0	136.0	41.3	3.3	301.1	1121.5
5.0	5.0	175.0	44.1	4.0	438.6	1633.6
6.0	6.0	230.0	74.2	3.1	489.1	1821.8
7.0	7.0	315.0	104.3	3.0	658.4	2452.7
8.0	8.0	430.0	134.4	3.2	934.2	3479.7
9.0	9.0	575.0	164.4	3.5	1325.2	4936.4
10.0	10.0	750.0	194.5	3.9	1845.0	6872.6
11.0	11.0	955.0	224.6	4.3	2507.8	9341.4
12.0	12.0	1190.0	254.7	4.7	3327.8	12396.0
13.0	13.0	1455.0	284.7	5.1	4318.9	16088.0
14.0	14.0	1750.0	314.8	5.6	5494.7	20467.6
15.0	15.0	2075.0	344.9	6.0	6868.1	25583.6
16.0	16.0	2430.0	375.0	6.5	8451.9	31483.3
17.0	17.0	2815.0	405.0	6.9	10258.4	38212.5
18.0	18.0	3230.0	435.1	7.4	12299.6	45816.1
19.0	19.0	3675.0	465.2	7.9	14587.3	54337.6
20.0	20.0	4150.0	495.3	8.4	17132.8	63819.8

STREAM RATING STONY BROOK D/S OF S.W.D. #28 (2.5 TO 4.0 MI.)

26/34

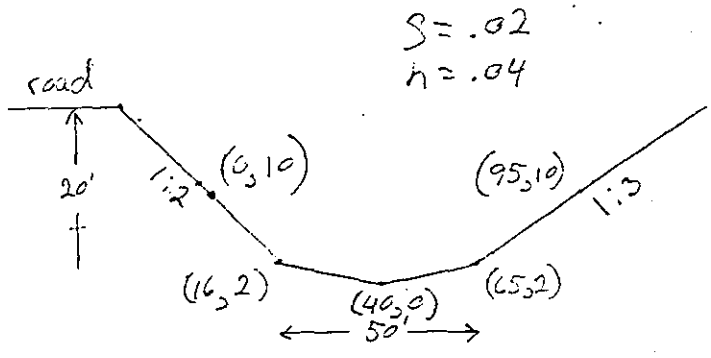
Q_{p2}	D_2	A_2	Vol
3480	8.0	430	130.4
4940	9.0	575	144
6870	10.0	750	160.4
9340	11.0	955	179.5

$$Vol = 203\left(1 - \frac{Q_{p2}}{9500}\right)$$

guess $Q_{p2} = 5000 \Rightarrow Vol = 124.6$

use Q_{p1} 4500 138.4

Estimate Peak Flow 5.0 miles d/s of SWD #28



Approx. Section of Stony Br.
d/s of Stockwell Br. (4+5 mi. d/s SWD #28

A rating table based on this stretch is shown on the following page

DEPTH	ELEV	AREA	WPER	HYD-R	AR2/3	Q
0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	0.5	3.1	12.3	0.2	1.2	6.4
1.0	1.0	12.3	24.6	0.5	7.7	40.6
1.5	1.5	27.6	36.9	0.7	22.7	119.6
2.0	2.0	49.0	49.2	1.0	48.9	257.6
2.5	2.5	74.2	52.2	1.4	93.8	494.3
3.0	3.0	100.9	55.3	1.8	150.7	793.7
3.5	3.5	129.0	58.3	2.2	218.9	1153.3
4.0	4.0	158.5	61.4	2.6	298.4	1571.8
4.5	4.5	189.5	64.5	2.9	388.9	2048.9
5.0	5.0	221.9	67.5	3.3	490.6	2584.6
5.5	5.5	255.7	70.6	3.6	603.5	3179.4
6.0	6.0	291.0	73.6	4.0	727.7	3833.7
6.5	6.5	327.7	76.7	4.3	863.4	4548.4
7.0	7.0	365.9	79.7	4.6	1010.7	5324.4
7.5	7.5	405.5	82.8	4.9	1169.8	6162.5
8.0	8.0	446.5	85.9	5.2	1340.9	7063.8
8.5	8.5	489.0	88.9	5.5	1524.2	8029.3
9.0	9.0	532.9	92.0	5.8	1719.9	9060.1
9.5	9.5	578.2	95.0	6.1	1928.1	10157.4
10.0	10.0	625.0	98.1	6.4	2149.3	11322.2

STREAM RATING

STONY BROOK
D/S OF STOCKWELL BROOK

$$Vol = \left(\frac{A_1 + A_2}{2}\right) \times L$$

$L = 5280'$

$A_1 = 325$

$A_2 = f(Q_{p2})$

Q_{p2}	D_2	A_2	Vol
2030	4.5	190	32.1
2580	5.0	222	34.1
3180	5.5	256	36.2
3830	6.0	291	38.4
4500	6.5	325	40.5

$$Vol = 263\left(1 - \frac{Q_{p2}}{4500}\right)$$

guess $Q_{p2} = 3900 \Rightarrow Vol = 38.4$

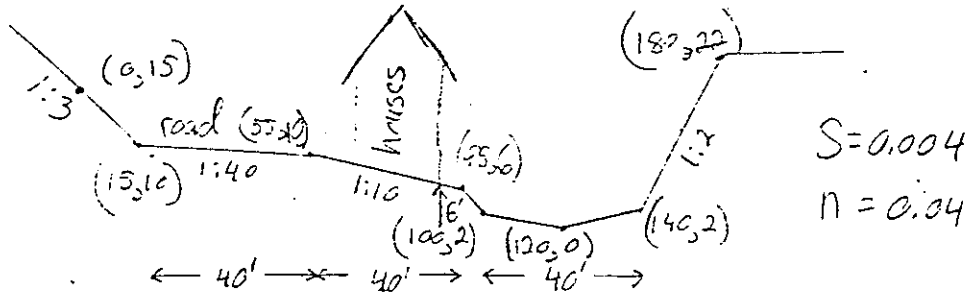
3800 40.9

4000 29.2

use $Q_{p2} = \underline{\underline{3900 cfs}}$

Neglect attenuation behind the small run-of-the river dam at the end of this reach, because the temporary storage here, with a pond area of only 2± acres, would be negligible.

Estimate flood depths outside of Wilton due to failure of SWD # 28.



Approx. Section of Stony Brook

~ 1/4 mile u/s of Wilton

The following rating table is based on FIS profiles at this point along Stony Brook.

TR	Q	Depth of Flow
10 yr.	2900 cfs	9.1 ft.
50	4700	11.6
100	5700	12.8
500	8100	14.5

Note that the attenuated dam break discharge estimated to be 3900 cfs (not including additional Stony Brook flows) would cause flooding

to a depth of 10'± above the streambed. There are in this vicinity seven houses, with first floor levels ranging from approximately 6' to 10' above the stream bed, which would be susceptible to serious damage as a result of this level of flooding.

However, FIS flood frequency analysis indicates that this degree of flooding is not unprecedented.

Test Flood Analysis

Size Classification -- Small

Storage < 1000 AF

Height < 40'

Hazard Classification -- Significant

Dam failure would probably result in serious flooding to homes along Stony Brook outside of Wilton 25 miles d/s of the dam. This far d/s, the flood wave has been much attenuated and the rate of rise should be relatively slow, reducing the potential for loss of life.

Railroad and roadway crossings of Stony Brook downstream would also be damaged.

Test Flood Selection

Per COE guidelines, a SMALL dam with SIGNIFICANT hazard potential should use a 100 yr. to 1/2 PMF Test Flood. As a complete inflow hydrograph of the order of magnitude of the 1/2 PMF, as well as the routed peak outflow, has been developed for this dam by the SCS, the peak value of this hydrograph will

be selected as the Test Flood.

Emergency Spillway. Hydrograph developed by SCS as part of the design calculations using SCS Unit Hydrograph.

Peak Inflow

$Q = 1168$ cfs (adopt as Test Flood)

check using COE NED "Maximum Probable Flood Peak Flow Rates"

Watershed -- rolling to mountainous

Drainage Area 608 acres = 0.95 sq. mi.

Use PMF = 2300 CSM

$= 2300 \times 0.95 = 2190$ cfs

1/2 PMF = 1090 cfs ✓

After storage routing through the reservoir, the peak outflow was calculated by the SCS to be 430 cfs. Storage routing was started at the 6-day drawdown level, elev. 835.5.

From the dam rating curve, this outflow of 430 cfs will occur with a pool elev. of approximately 851.2 MSL, 1.8 feet below the crest of the dam.

Drawdown Time

Sheet 5-2 of the SCS design calculations contains a drawdown time check

Beginning at the level of the emergency spillway crest, elev. 850.0, and assuming no inflow the 6-day drawdown level would be 835.5 (14.5')

APPENDIX E

INFORMATION AS CONTAINED IN

THE NATIONAL INVENTORY OF DAMS